SCIENTIFIC AGRICULTURE

VOLUME 29 MARCH, 1949 No. 3

# THE VARIETAL COMPOSITION OF CANADIAN EXPORT WHEAT, 1926-1946[1]

## A STUDY BASED ON TWENTY ANNUAL ANALYSES OF EXPORT CARGOES

J. G. Carl Fraser[2]

[Received for publication August 3, 1948]

Canada's enviable reputation as a wheat producing country is built on the high quality of the wheat which she exports to other countries. Constant vigilance, however, has been necessary in order to maintain this high standard of excellence. In this, various agencies contribute, among which may be mentioned, first of all, the plant breeder who has given us good varieties. Next in importance, perhaps, is the Canadian Seed Growers' Association whose members multiply these approved varieties in a pure state and whose function is greatly aided and encouraged by the far-flung influence of the various Departments of Agriculture and Universities, and by such crop improvement agencies as those promoted by "The Crop Testing Plan", "The Line Elevators" and "The Wheat Pools". Then the general wheat producer applies his skill in producing and handling the commercial grain, and, finally, The Board of Grain Commissioners see to it that all wheat merchanised for domestic use or for export is given its proper grade.

About 1925, the wheat which Canada was producing was being criticized in certain quarters because of the "undesirable mixture of varieties" of which it was believed to be composed. The Department of Agriculture, through the Cereal Division, Experimental Farm Service, initiated an annual survey of the varietal composition of the wheat composing a large number of cargoes, in order to obtain factual information on this point and, incidentally, to follow the expansion of the areas devoted to recently introduced varieties. At the beginning, these samples were drawn from cargoes of Canadian wheat as they arrived in Great Britain; but it was soon considered more desirable to have samples taken by officials of the Department of Trade and Commerce in Canada prior to shipping. Accordingly, arrangements were made whereby this material was collected by the staff of the Chief Grain Inspector, Board of Grain Commissioners, Winnipeg. The samples were taken while the ships were being loaded, which meant that the collecting period extended over a considerable length of time. Actually, in the case of boats loaded at Eastern ports, the collections are made from early September until the close of navigation in December. Boats loaded at Vancouver, on the other hand, are sampled from October until February.

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[1] Published as Paper No. 140 of the Cereal Division, Central Experimental Farm, Ottawa, Ontario.

[2] Agricultural Scientist in charge of Wheat Investigations, Cereal Division, Central Experimental Farm Ottawa, Ontario.

The data from the 1931 crop onward, therefore, are based chiefly on samples drawn in Canada by the Chief Grain Inspector's office. Data for the years 1926-1931 are also submitted, but these were obtained from "The Export Standards Grade" samples put up each season by the Grain Standards Committee to indicate the grading of the current year's crop. The latter samples, however, are of necessity put up from material gathered early in the season and are not thought to be truly as representative as the material on which the main part of this report is based.

The number of samples handled over the period 1931-1946, is indicated in Table 1.

TABLE 1.—PORTS FROM WHICH SAMPLES WERE OBTAINED

| Grade | Vancouver | Fort William | Churchill | Montreal | Total |
|---|---|---|---|---|---|
| 1 Northern | 404 | 455 | 26 | 25 | 910 |
| 2 Northern | 383 | 456 | 34 | 4 | 877 |
| 3 Northern | 367 | 454 | 19 | 25 | 865 |
| 4 Northern | 46 | 177 | — | — | 223 |
| Total | 1200 | 1542 | 79 | 54 | 2875 |

## CANADIAN WHEAT VARIETIES

In order to obtain some idea of the scope of what is involved in this study, a reference to the history of wheat-growing in Canada and the expansion of the Canadian northwest is necessary. (The author has drawn extensively on "Essays on Wheat", by H. H. Buller for much of the following information.)

The first recorded attempts at the growing of wheat in Canada's Northwest were made by the Selkirk Settlers. This little band of pioneers was brought out from Scotland by Lord Selkirk to colonize 100,000 square miles of territory granted to him by the Hudson's Bay Company. The advance party arrived in August, 1812, and immediately commenced breaking sod in preparation for the next year's crop. Part of this was sown to winter wheat which they had brought with them. No crops were harvested, however, until 1815, as many tribulations dogged the efforts of the settlers. Early frosts, grasshoppers, plagues, ravages by birds and rival fur-traders all contributed to making wheat-growing extremely hazardous. Of the varieties in use at that time, nothing very definite is known, but, from the records, we are able to gather certain information. In 1868, the crop was almost entirely destroyed by grasshoppers and new seed was brought in from the United States. This wheat came chiefly from Minnesota, and probably was composed largely of Red Fife which had come into that State from Ontario. At any rate, further records show that small amounts of this variety were grown in Manitoba in 1870. In 1876, nearly 1,000 bushels of Red Fife seed were sent to Ontario for sowing in that province. This was the first wheat exported from Western Canada.

With the opening up of the country by the Canadian Pacific Railway, Red Fife seed was brought in from Minnesota and this was the variety sown by the company on all farms which it broke out of virgin sod as the

railway advanced across the prairies. The inducements extended by the Government in dropping the duty on imported seed wheat, and the offer of free transportation by the railway, gave the importation of this seed an added impetus. Thus Red Fife became the foundation on which Canada's reputation as a wheat-growing and exporting country was founded. Incidentally, Red Fife is found in the pedigree of the large majority of the good hard red spring wheats grown in Canada to-day.

While Red Fife was a good wheat from a quality standpoint, it was found to be too late in maturity for many parts of the Prairie Provinces. One of the first steps taken by the Dominion Experimental Farm System on its inauguration in 1886 was the extensive search for earlier maturing wheats (3). The story of this quest is a most compelling one, extending as it does over a long period of years. While several early wheats of good quality were produced, Marquis, introduced in 1909, was definitely the most outstanding. This variety, resulting from a cross made in 1892 between Red Fife and Hard Red Calcutta, swept the country as no other wheat has ever done. It has been estimated that by 1910 this variety composed 90 per cent of the hard red spring wheat grown in Canada and the United States. Marquis assumed such a prominent place in Canadian agriculture that it was adopted as the "yard stick" by which other varieties must be measured in so far as quality is concerned.

Many other varieties have been tried and discarded or released, but only those found in our export wheat at the start of this study are herewith listed. The others are rarely, if ever, found and are, therefore, of no interest as far as this study is concerned. The varieties are listed in the order in which they were grouped when this investigation was first initiated. (For further description of these varieties, see Handbook of Canadian Spring Wheat Varieties (4).)

| Variety | Parentage |
|---|---|
| Marquis | Red Fife × Hard Red Calcutta |
| Garnet | Preston A × Riga M |
| Reward | Marquis × Prelude |
| Thatcher | (Marquis × Iumillo) × (Marquis × Kanred) |
| Apex | (H-44-24 × Double Cross) × Marquis |
| Renown | H-44-24 × Reward |
| Regent | H-44-T × Reward |
| Red Fife | Selection from Russian sources |
| Renfrew | Selection from Marquis |
| Ruby | Down Riga × Red Fife D |
| Red Bobs | Selection from Bobs |
| Ceres | Kota × Marquis |
| Early Red Fife | Selection from Red Fife |
| Type IC | Selection from Red Fife |
| Percy | Ladoga × White Fife |
| Reliance | Kanred × Marquis |
| Canus | Marquis × Kanred |
| Kota | Selection found in Durum |
| Coronation | Pentad × Marquis |
| Quality A | Burbank's Selection from Florence |
| Federation | Yandilla King × Purple Straw |
| Huron | Ladoga × White Fife |
| Pioneer | Riga × Preston |
| Preston | Ladoga × Red Fife |
| Stanley | Ladoga × Red Fife |
| Fisher's Selection | Selection from Marquis |

*Continued on page 100*

| Variety | Parentage |
|---|---|
| Parker's Selection | Selection from Marquis |
| Prelude | Downy Gehun × Fraser |
| Miscellaneous | Varieties resulting from natural crosses and otherwise |
| Ladoga | A variety of Russian origin |
| White Russian | A variety of Russian origin |
| Broatch's Selection | Selection made by J. W. Broatch |
| Club | A compactum type of wheat |
| Speltoid | A Spelt-like wheat type arising in common wheat varieties |
| Durum | Durum type wheats |

OTHER CROPS SOMETIMES FOUND IN EXPORT WHEAT

| | |
|---|---|
| Rye | Tame Oats |
| 6 Row Barley | Wild Oats |
| 2 Row Barley | |

In making the analysis on these samples representing the individual grades everything found in the sample, including rye, barley and oats, was analysed and recorded, although they add little to the data and are generally within the limits for "foreign material other than wheat" allowed in the grade definitions.

## ANALYSES OF EXPORT STANDARD GRADES—1926-1930

The data from the three Export Standard Grades 1, 2 and 3 Manitoba Northern are presented at this time primarily to give the reader an indication of the number of varieties and the percentages of each found in the Standards, at the time when criticism first arose. In this way it will be possible to follow the trend in both the number and the percentage of these varieties from 1926 to 1930 before the cargo samples were secured from the Chief Grain Inspector and made available for further study.

It will be noted in Table 2 that in 1926 over two-thirds of the wheat in the three Manitoba Northern Grades was composed of the Marquis variety, with the next largest percentages made up of Type IC, Renfrew, Kitchener and "Miscellaneous" types. In the succeeding four years, Red Fife increased and declined again, no doubt lagging behind the cycle of rust years when damage by rust or early frost would place this variety in the "Feed" grades. It was interesting to note that the Garnet and Reward varieties did not appear in the two top grades for two years after their introduction to the wheat-growing areas, but Garnet was found in the 3 Manitoba Northern Grade the first year after its introduction in 1926. Ceres appeared for the first time in 1928 and Reward in 1930. The Red Bobs Selections, made up of the Red Bobs, Early Triumph and Supreme varieties and grouped together throughout this varietal survey, are found in greater amounts in the 3 Manitoba Northern than in the higher grades. Ruby, first introduced as a war measure in 1916, had an up-surge in the top grade in 1928 when it reached an all-time high of 17.6 per cent, but it has been declining ever since. Early Red Fife reached its peak in the 1 and 2 Manitoba Northern in 1929. The other varieties, mostly of medium and poor milling and baking quality, were found in small or trace percentages, but have been recorded in order to provide as complete a picture as possible of what was actually found in Canadian Export Wheat during this period.

TABLE 2.—VARIETAL ANALYSIS OF EXPORT STANDARD GRADES FOR YEARS 1926-27-28-29-30. (PERCENTAGE)

| | Grade 1 Manitoba Northern | | | | | | Grade 2 Manitoba Northern | | | | | | Grade 3 Manitoba Northern | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1926 | 1927 | 1928 | 1929 | 1930 | Average | 1926 | 1927 | 1928 | 1929 | 1930 | Average | 1926 | 1927 | 1928 | 1929 | 1930 | Average |
| Marquis | 66.01 | 77.05 | 53.61 | 61.39 | 76.80 | 66.97 | 72.02 | 68.72 | 59.69 | 44.39 | 66.97 | 62.36 | 62.75 | 53.65 | 52.70 | 43.47 | 52.47 | 53.01 |
| Garnet | — | — | 0.27 | 0.36 | 3.31 | 0.79 | — | — | 3.78 | 14.24 | 15.01 | 6.61 | — | 1.52 | 2.52 | 14.85 | 11.71 | 6.16 |
| Reward | — | — | — | — | 2.00 | 0.40 | — | — | — | — | 0.85 | 0.17 | — | — | — | — | 0.27 | 0.05 |
| Red Fife | — | 2.36 | 14.25 | 14.02 | 3.76 | 6.88 | 1.48 | 3.09 | 14.41 | 11.43 | 6.23 | 7.35 | 5.03 | 3.96 | 19.58 | 13.34 | 8.07 | 10.00 |
| Ruby | 1.96 | — | 17.69 | 0.48 | 2.58 | 4.54 | — | 1.40 | 2.68 | 1.68 | 1.31 | 1.41 | — | 12.50 | 2.70 | 4.49 | 0.40 | 4.02 |
| Red Bobs Sel. | 0.65 | 1.76 | 0.37 | 2.39 | 0.37 | 1.10 | 0.29 | — | 1.22 | 5.27 | 0.33 | 1.43 | 1.34 | 6.70 | 4.40 | 3.34 | 3.53 | 3.87 |
| Ceres | — | — | 0.08 | 0.60 | 1.47 | 0.43 | — | — | — | 0.56 | 0.72 | 0.26 | — | — | 0.06 | 0.69 | 0.20 | 0.19 |
| Early Red Fife | 1.96 | 0.88 | 1.52 | 3.59 | 0.15 | 1.62 | 0.89 | — | 1.25 | 3.03 | — | 1.03 | 2.34 | 5.79 | 1.25 | 1.84 | 0.33 | 2.31 |
| Type IC | 5.55 | 0.29 | 4.87 | 6.11 | 4.35 | 4.23 | 1.48 | 5.39 | 1.55 | 6.05 | 2.23 | 3.34 | 2.34 | — | 3.16 | 4.49 | 12.80 | 4.56 |
| Kota | 1.63 | 0.58 | 0.57 | 0.72 | 1.25 | 0.95 | 0.59 | 0.57 | 1.71 | 0.67 | 0.72 | 0.85 | 1.34 | 0.91 | 0.39 | 0.35 | 1.13 | 0.82 |
| Pioneer | — | — | — | — | 0.22 | 0.04 | — | — | 0.31 | 0.34 | 0.20 | 0.17 | — | — | — | — | — | — |
| Renfrew | 3.59 | 3.82 | 0.78 | 2.15 | 0.52 | 2.17 | — | 3.66 | 3.22 | 1.91 | 0.72 | 1.90 | 3.02 | 0.91 | 1.36 | 0.35 | 0.60 | 1.25 |
| Kitchener | 5.25 | 2.05 | 1.36 | 6.11 | 0.30 | 3.01 | 3.86 | 2.54 | 4.27 | 4.37 | 0.20 | 3.05 | 4.68 | 1.82 | 5.65 | 3.68 | 1.13 | 3.39 |
| Huron | 0.98 | 0.58 | 0.15 | — | — | 0.34 | 1.48 | 1.40 | 0.17 | 1.12 | — | 0.83 | 1.34 | 1.82 | 0.32 | 1.15 | 0.07 | 0.94 |
| Preston | — | 0.29 | 0.14 | — | 0.15 | 0.12 | — | — | 0.17 | 0.45 | 0.33 | 0.19 | — | — | 0.37 | 0.35 | 0.07 | 0.11 |
| Stanley | — | — | — | 0.48 | — | 0.10 | 0.59 | 0.28 | 0.35 | 1.12 | 0.46 | 0.56 | — | 0.30 | 0.53 | 1.38 | 0.47 | 0.54 |
| Parkers Sel. | — | — | — | — | 0.30 | 0.06 | — | — | — | — | 0.39 | 0.08 | — | — | 0.06 | 0.23 | .20 | 0.09 |
| Fishers Sel. | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.07 | 0.01 |
| Miscellaneous | 12.41 | 10.29 | 2.67 | 0.96 | 1.40 | 5.55 | 16.96 | 12.95 | 3.47 | 1.79 | 2.88 | 7.61 | 15.76 | 9.44 | 2.93 | 2.77 | 4.00 | 6.98 |
| Ladoga | — | — | 1.60 | 0.36 | 0.66 | 0.24 | — | — | 1.51 | 1.35 | 0.26 | 0.62 | — | — | 1.87 | 3.11 | 1.07 | 1.21 |
| Federation | — | — | — | — | 0.22 | 0.04 | — | — | — | — | — | — | — | — | — | — | — | — |
| Club | — | — | — | — | — | — | — | — | — | — | 0.07 | 0.01 | — | — | — | — | — | — |
| Vermilion | — | — | — | — | — | — | — | — | 0.06 | 0.11 | — | 0.03 | — | — | — | — | — | — |
| Speltoid | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.30 | — | — | 0.47 | 0.15 |
| Durum | — | — | — | — | 0.15 | 0.03 | — | — | 0.13 | — | — | 0.03 | — | — | 0.12 | 0.12 | 0.40 | 0.13 |
| 6 Row Barley | — | — | — | — | 0.07 | 0.01 | — | — | — | — | 0.07 | 0.01 | — | — | — | — | 0.47 | 0.09 |
| 2 Row Barley | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.07 | 0.01 |
| Tame Oats | — | — | — | — | — | — | 0.29 | — | — | — | 0.07 | 0.07 | — | 0.30 | — | — | — | 0.06 |
| Wild Oats | — | — | — | 0.24 | — | 0.05 | — | — | — | 0.11 | — | 0.02 | — | — | — | — | — | — |

On examination of the five-year averages, it will be noted that the varieties which are now eligible to go into the 1 and 2 Manitoba Northern Grades (4), make up the following percentages of these grades.

| | 1 M.N. per cent | 2 M.N. per cent | 3 M.N. per cent |
|---|---|---|---|
| Marquis | 67.97 | 62.36 | 53.01 |
| Reward | 0.40 | 0.17 | 0.05 |
| Red Fife | 6.88 | 7.35 | 10.00 |
| Ruby | 4.54 | 1.41 | 4.02 |
| Red Bobs Selection | 1.10 | 1.43 | 3.87 |
| Ceres | 0.43 | 0.26 | 0.19 |
| Early Red Fife | 1.62 | 1.03 | 2.31 |
| Type IC | 4.23 | 3.34 | 4.56 |
| Pioneer | 0.04 | 0.17 | — |
| Renfrew | 2.17 | 1.90 | 1.25 |
| | 89.38 | 79.42 | 79.26 |

The following varieties were not grown in this period:

Thatcher, Apex, Renown, Regent.

It is evident from these data that the introduction of the new varieties had the tendency to reduce the percentage of mediocre and poor quality wheat varieties rather than having the opposite effect as was claimed by some; nor has the trend in later years lent any support to this latter claim. This will be brought out in the discussion in the text based on the tables to be found in the Appendix of this report.

## *Trends in Overseas Cargoes*

### ATLANTIC CARGOES

With the trends indicated in the Export Standard Grades as a background, let us now examine the "Official Samples" supplied by the Chief Grain Inspector for the crop years 1931-1946, inclusive, except for those belonging to the 1942 crop year. The samples from the 1942 crop, when grown at Ottawa, suffered so badly from adverse weather that the varietal data were not considered sufficiently reliable and have therefore, not been included in Tables A1 to A12 which are to be found in the Appendix.

*1 Manitoba Northern Grade Samples*
*Ex Fort William, Ontario*

A close study of Table A1 which deals with the 1 Manitoba Northern Grade shipped from Fort William, Ont., reveals extremely interesting trends in the varietal make-up of this grade over the period studied. It will be noted that Marquis held a premier position until 1937 when a series of events took place which have had a marked effect on the varietal composition of our wheats. That year, stem rust and drought were both serious, and seed was brought in from Alberta to relieve the shortage in supply caused by a succession of poor crops in Saskatchewan. One of the varieties grown to a considerable extent in Alberta was Red Bobs; this accounts for the sudden increase noted in the percentage of this variety in

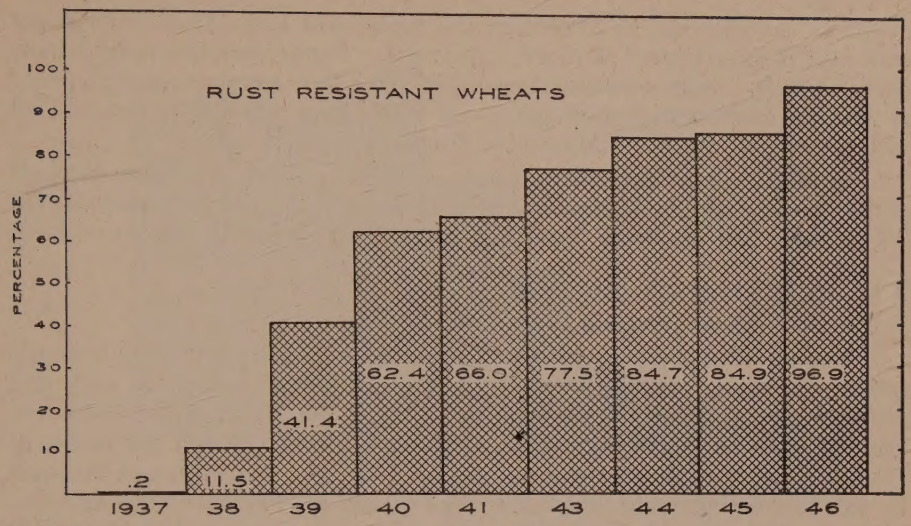


FIGURE 1. Increase in percentage of rust-resistant wheats in 1 Manitoba Northern cargoes. Ex Fort William, 1937-1946, inclusive.

this 1 Manitoba Northern Grade in 1937. It has declined steadily from that time to date. Thatcher wheat, a stem rust-resistant variety developed at the University Farm, St. Paul, Minnesota, was just making its appearance at this period, having been introduced into Canada in 1935. This new wheat survived the stem rust and drought better than "the relief seed", and from then on Thatcher has increased very rapidly. By 1945, 80 per cent of this grade was made up of this one variety. In 1939, two new rust-resistant wheats, Apex and Renown, were just appearing in the cargoes and Regent followed a year later. With the introduction of these four new rust-resistant wheats there followed a rapid and almost complete decline in the percentages of the rust-susceptible varieties grown. This condition has been quite marked in the last six years when the average percentage of rust-resistant varieties has increased from 2.2 per cent in 1937 to 96.9 per cent in the samples analysed for 1946. This is graphically represented in Figure 1.

A glance at Table A1 further shows that the various other varieties in this grade have also been declining rapidly and by 1946 had either disappeared or were only found in minute quantities.

It should be borne in mind when examining these data that Table A1 in the Appendix represents anywhere from twenty-five to fifty cargoes for any one year and that, in the average itself, the percentage of any one variety indicated may be made up from only a few cargoes. In other words some varieties may occur a relatively few times, while others will be found in every crop year. For instance, Marquis was found in every cargo of 1 Manitoba Northern in 1931, ranging from 51.7 per cent to 83.4 per cent in individual cargoes. Type IC on the contrary ranged from 0.4 to 20.1 per cent. In the 1946 cargo samples Marquis was found in only twenty of the twenty-five cargoes and ranged from zero to 5.0 per cent, while Thatcher and Regent were in every one of the twenty-five

cargoes. In the case of Thatcher, the range was from 32.4 to 94.4 per cent and Regent from 1.4 to 49.7 per cent. Other varieties ranged from zero upwards. Instances have been observed where a large cargo composed of 340,000 bushels was made up of not more than seven varieties and all of those eligible for the 1 Manitoba Northern Grade.

In 1931, when official samples were first supplied, Marquis, Reward and Type IC were the leading varieties in the 1 Manitoba Northern Grade. These three varieties made up a total of 84.5 per cent of the wheat verified.

*2 Manitoba Northern Grade Samples*
*Ex Fort William, Ontario*

The trend in the samples taken from the 2 Manitoba Northern Grade follows the same general course as in the preceding grade, but with this difference: The Marquis content in 1931 to 1934 remained at much the same level, with Garnet taking a close second place. When the policy of grading Garnet separately was adopted in 1935, the percentage of Marquis in this grade increased until the appearance of the new rust-resistant varieties began to manifest itself. Since then Marquis has decreased very rapidly until by 1944 it reached a negligible place.

The bad rust year, 1936, had the same effect on the 2 Manitoba Northern Grade as already noted in the higher grade, with a decrease in Marquis and an increase in Red Bobs Selection in 1937. From 1939 on, the rust-resistant varieties have taken up a large percentage of this grade. In that year, the four varieties, Thatcher, Apex, Renown and Regent made up 60.5 per cent of the grade and this percentage increased to 89 per cent in 1944, then dropped to 85 per cent in 1945 and in 1946 reached 96.5 per cent of the grade. There was a corresponding gradual tapering off in such varieties as Red Fife, Ruby, Pioneer, Kota, Coronation and Type IC in the same years. Actually, only Type IC of these six varieties appeared in the 1946 crop samples. While the actual number of varieties between 1931 and 1946 had changed only slightly, the percentage of many has noticeably lessened. Many mediocre and poor quality wheats have been replaced by good rust-resistant varieties.

In this grade the percentages of rust-resistant wheats have gradually increased over the last nine-year period, with the average just slightly lower than for the average of the next grade above. This is clearly to be seen in the Figure 3.

*3 Manitoba Northern Grade Samples*
*Ex Fort William, Ontario*

In the 3 Manitoba Northern Grade, much the same trends are noted as in the Grades 1 and 2. The percentage of Marquis reached its peak in 1935 and after 1938 declined rapidly, being replaced chiefly by the rust-resistant wheat variety Thatcher, which reached its highest percentage for the fifteen-year period in 1946. The other rust-resistant wheats, Apex and Renown, appeared in this grade in 1939 with Regent appearing a year later. By 1940, the percentage of these four resistant wheats comprised 68.4 per cent of the wheat in this grade and the peak for these varieties was reached in 1946 when the percentage hit 92.9 per cent. It declined in 1944 but rose again to 82.6 per cent in 1945, with an average for the fifteen-year period of 37.6 per cent.

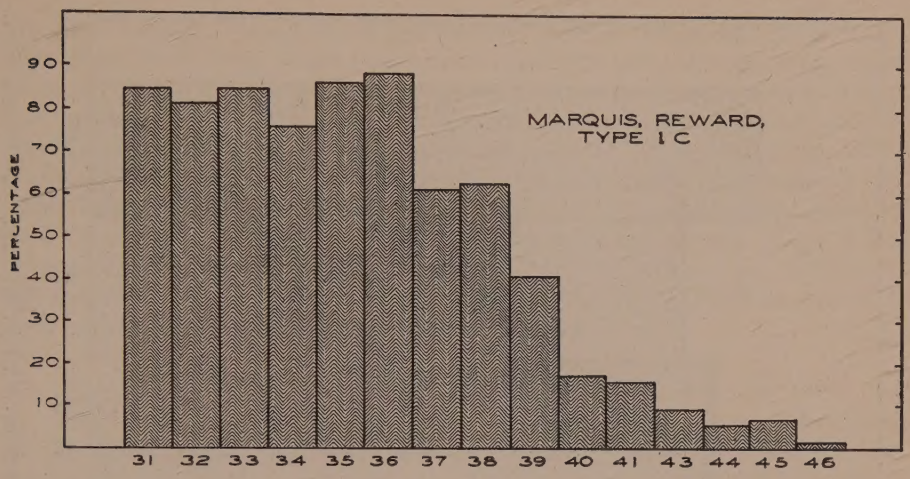


FIGURE 2. Combined percentages of Marquis, Reward and Type IC wheats found in 1 Manitoba Northern cargoes. Ex Fort William, 1931-1946, inclusive.

Red Bobs was relatively unimportant until 1938, when it increased to 21 per cent. It, however, decreased to a low of 1.1 per cent in 1946, and was largely replaced by Thatcher. For the fifteen-year period, Red Bobs ranked fourth in the average percentage of the varieties comprising this grade.

The twenty-five cargoes of the grade examined each year for the period 1941 to 1946 indicate that from 95.8 to 97 per cent of the grade was made up of the following six varieties: Marquis, Thatcher, Apex, Regent, Renown and Red Bobs; and in only one case did the percentage of any of these varieties fall below 1 per cent of the total (Marquis 0.27 per cent in 1944).

Garnet reached its maximum percentage in 1937, then decreased to obscurity as in the other Northern grades. Reward, which in 1934 made up 8.8 per cent, had steadily declined until by 1946 it reached trace proportions.

*4 Manitoba Northern Grade Samples*
*Ex Fort William, Ontario*

The data in Table A4 in the Appendix provide information on the 4 Manitoba Northern Grade for an eight-year period only. They indicate that the trend in the varieties of wheat found in these cargoes from Fort William remains much the same as in the other grades already discussed. The percentage of Marquis, starting at 55.2 per cent in 1938, declined rapidly after 1940, reaching a low point of less than $\frac{1}{2}$ of one per cent in 1944, but rising slightly in 1945 to 11.0 per cent and again dropping to less than 5 per cent in 1946. Marquis was largely replaced by the Thatcher variety which, along with the other rust-resistant wheats, including Apex, Renown and Regent, has steadily assumed a greater share of the total. This is brought out in the accompanying histogram (Figure 4).

The combined percentages of the following seven wheats—Marquis, Reward, Thatcher, Apex, Renown, Regent and Red Bobs have been exceptionally high in relation to the other varieties found in this 4 Manitoba

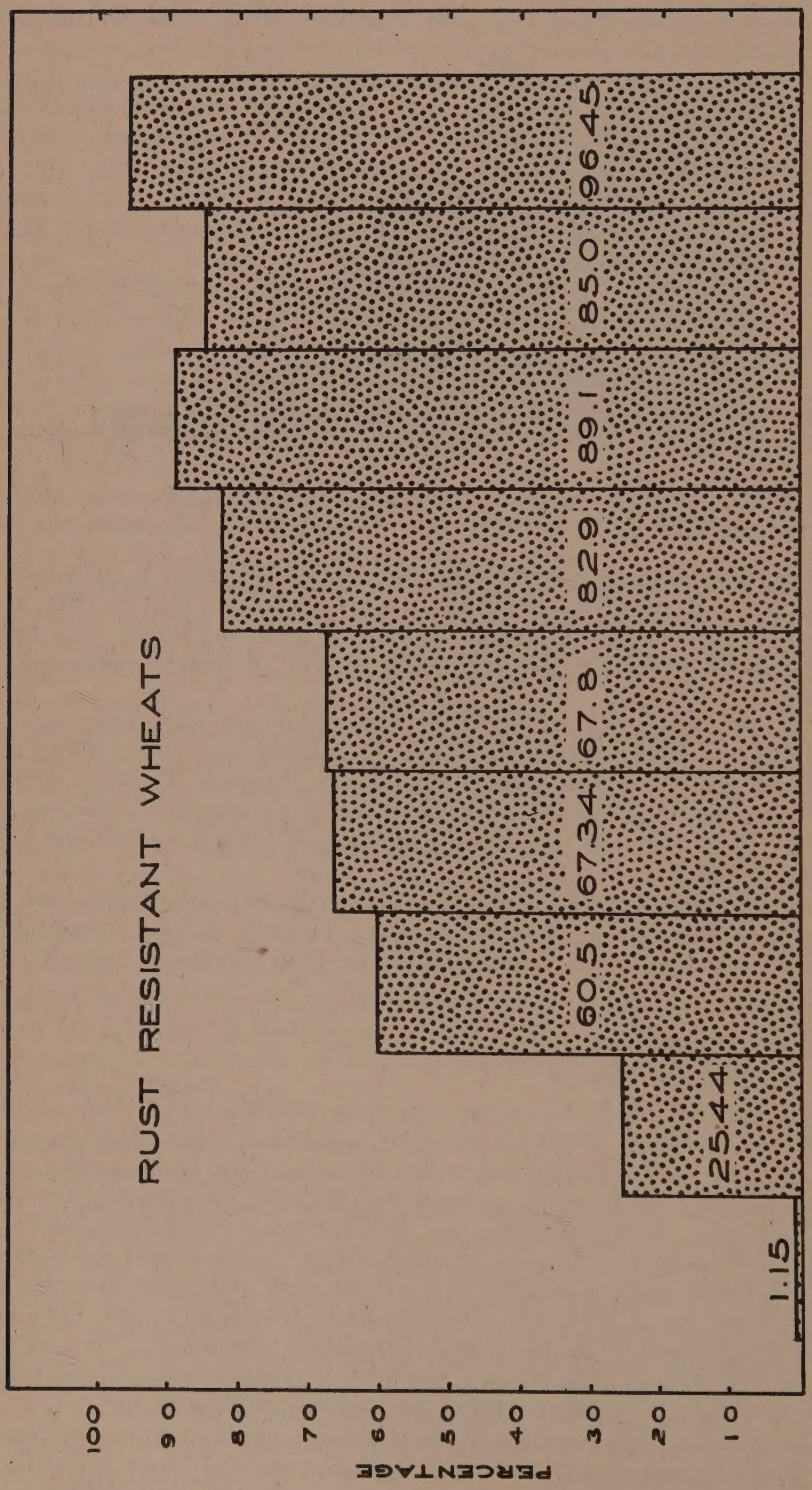


FIGURE 3. Combined percentages of Thatcher, Apex, Renown and Regent in 2 Manitoba Northern cargoes. Ex Fort William, 1937-1946, inclusive.

Northern Grade. There has never been a year in the period under consideration (1938-1946) when these seven varieties have not made up from 90 to 97.8 per cent of the total wheat in this grade, except in 1938 when this figure was only 81.6 per cent. During the above period, Reward has steadily declined from 8.2 per cent to zero in 1946. The interesting point in this Grade is the fact that the number of wheat varieties making up the Grade has never been as high as in the higher grades. The range covered from 25 varieties in 1943 to only 16 in 1946, when as already noted, 97.8 per cent of the grade was made up of less than seven varieties. Many of the varieties found in the earlier years were either only found in traces or were entirely absent from the 1946 crop samples.

## PACIFIC CARGOES

The varietal composition of the wheat shipped from the Pacific Coast of Canada has not undergone the radical change which has characterized that produced in areas farther east during the period under investigation. This is due primarily to the fact that Alberta lies well to the west of the area where rust may be a serious factor. Farmers in this area, therefore, have not found it so necessary to change over to varieties capable of resisting this disease. Throughout the fifteen crop years studied, Marquis and Red Bobs have been consistently the two outstanding varieties in so far as the percentage grown is concerned. In more recent years, Thatcher and some of the other rust-resistant varieties have made appreciable gains due to their yielding ability rather than to their rust-resistance. The suitability of Red Bobs as a combine wheat, where this method of harvesting is practised in Alberta, has been an important factor in the continued popularity of this variety in this province. Being highly susceptible to wheat stem rust, however, Red Bobs has practically disappeared from the provinces farther east.

### *1 Manitoba Northern Grade Samples Cargoes Leaving Vancouver, B.C. (For Years 1931-1946, inclusive)*

Again referring to the Appendix, it may be noted in Table A5 that there is the same general trend in the percentage of Marquis found in the Manitoba Northern cargoes from Vancouver as is indicated in Table A1 dealing with 1 Manitoba Northern shipments from Fort William. The percentage of Marquis in the Pacific cargoes, however, is always lower than that from Fort William, with the exception of four years—1940, 1941, 1945 and 1946. The average for the period is approximately 10 per cent lower. Until 1937, the average annual percentages of Marquis in the Pacific cargoes were practically the same, but gradually declined after this date to reach a low of 0.29 per cent in 1944; an upward swing again occurred in 1945. Garnet and Reward followed similar paths in this grade from both east and west ports but, as might be expected from the statement already made, the rust-resistant wheat varieties in the Vancouver cargoes have not increased as rapidly as in their eastern counterparts. The percentage of Thatcher in 1944 crop was the first big upward surge indicating the increasing popularity of this variety. The average content of the four rust-resistant varieties that year made up 44.8 per cent of the cargoes,

declining to 16.7 per cent in 1945. Where the Vancouver cargoes have varied most noticeably has been in the Red Bobs content. From 1934, the average content of the latter variety has increased rapidly, reaching a high of 71.5 per cent in 1941, but has since declined from this level.

The number of wheat varieties found in this grade have closely followed those of the corresponding grade in the Fort William shipments, the difference being in the percentage of each variety found.

In 1931, Marquis, Reward, Red Fife and Red Bobs and Type IC were the main varieties contributing to the 1 Manitoba Northern Grade shipped from Vancouver, making up 85.6 per cent of the wheat in those shipments. From 1937 on, the percentage of those varieties, plus the four rust-resistant wheats as they came into the grades, has only been below 94.5 per cent once and in 1941 the percentage reached 97.2. The number of wheat varieties found in this 1 Manitoba Northern Grade cargoes from Vancouver does not seem to follow any well defined trend. The greatest number of varieties found in any year was 28 in 1933 and 1934 when 50 cargoes were examined, and the lowest was 13 in 1939 when only 13 cargoes were examined. In 1943 with twenty-five cargoes verified, the number of varieties was again up to 24, the greater number of cargoes examined per year naturally providing greater opportunity for additional varieties.

*2 Manitoba Northern Grade Samples*
*Ex Vancouver, B.C.*

This group of three hundred and eighty-four wheats provides no parallel with any of the other grades yet examined. The trends, as noted in Table A6 in the Appendix, are erratic and several crests appear in the main varieties making up these grade cargoes from the Port of Vancouver for the years concerned.

The percentage of Marquis over the fifteen-year period varies greatly, running with fair uniformity from 1931 to 1935 when it hit the highest level in the full period being considered. It then declined until 1941 when this variety again ran up to 43.6 per cent and receded to 1.3 per cent in 1944. In 1945 and 1946 the average Marquis content was over 12 per cent. The Garnet content of this 2 Manitoba Northern Grade was the high ranking variety until 1935 when the special grades which were introduced for this variety caused it to fall away into the "Trace" category. Reward did not make much headway in this grade and never averaged over 7.8 per cent. Thatcher, starting to appear in 1937, made rather slow progress in the Pacific Cargoes until 1943 when it jumped to 10.7 per cent and has steadily risen since then, making up nearly one-third of the percentage of this grade in 1946. It is likely to become one of the leading varieties in future.

None of the other varieties has a high content in this grade except Red Bobs which replaced Garnet as the leading variety from 1936 on; and for the fifteen-year period comprised on the average over 46 per cent of the wheat of this grade examined and shipped from this Pacific Port.

The number of varieties making up this 2 Manitoba Northern Grade has been consistently higher than in the grade above it. In fact, this whole grade presents a specially interesting study in that it has been

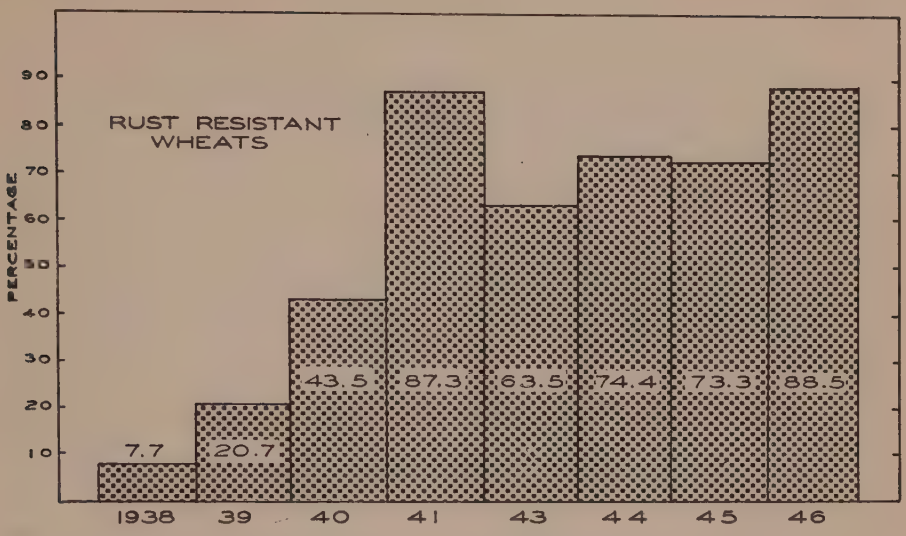


FIGURE 4. Combined percentages of rust-resistant wheat varieties in No. 4 Manitoba Northern cargoes. Ex Fort William, 1938-1946, inclusive.

practically carried on three varieties. At the start in 1931 with Marquis, Red Bobs and Garnet, making up 81 per cent of the total, and after 1935 when Garnet was placed in a special grade, Marquis, Red Bobs and Thatcher made up 76 to 93 per cent of this 2 Manitoba Northern Grade. In 1941, only two cargoes were sampled and the data for that year should be considered with caution in so far as the number of varieties comprising the grade for that year is concerned.

*3 Manitoba Northern Grade Samples*
*Ex Vancouver, B.C.*

The data found in Table A7 in the Appendix on these three hundred and sixty-seven 3 Manitoba Northern Grade samples provide interesting material for study. Into this grade has fallen material which has been disallowed in the higher grades, and yet it contains a high proportion of good milling and baking wheats over the fourteen-year period, 1942 and 1944 not being represented by samples from cargoes in these years.

The Marquis content of this grade fluctuated widely from 33.1 per cent in 1931 to 3.2 per cent in 1943, but has only followed this definitely downward trend since 1939, although three regressions have been noted in the fourteen-year period. The average for the period was approximately 12 per cent. Garnet, however, in the same period has roughly contributed 30 per cent of the wheat of this grade, although since 1937 it has dropped down to a low of 1.2 per cent in 1943. Thatcher was a year later in making its appearance in this grade than in 1 and 2 Manitoba Northern Grades but increased much more rapidly until by 1946 it comprised 40 per cent of the wheat in this grade. In fact, the percentage of Thatcher for that year in this grade is 10 per cent higher than in the two higher grades already examined and the data in Table 3 are given to bring this point out.

TABLE 3.—PERCENTAGE OF THATCHER WHEAT IN 1, 2 AND 3 MANITOBA NORTHERN GRADES

| Per cent | 1° | 2° | 3° |
|---|---|---|---|
| Thatcher | 27.9 | 31.2 | 40.0 |

The other rust-resisting wheats were not only delayed in appearing in this Grade, but never contributed materially to the total.

The Red Bobs selections have always been large contributors to the 3 Manitoba Northern Grade, but since 1938 have the major position, with the average content over the period just slightly higher than that held by Garnet, and over twice that of Marquis. The high percentage of this variety in 1941 should be considered in the same light as the cargoes of the 2 Manitoba Northern Grade, in that only two cargoes were sampled to provide these data. The high content of the twenty-five cargoes in 1943 and 1946 and the twenty in 1945, however, demonstrates that Red Bobs has continued to be the big contributor to this Grade. There does seem to be a slight tendency to decline in the face of the increasing popularity of Thatcher, which, as has been noted above, increased materially in the 1946 cargoes.

TABLE 4.—COMPARISON OF THE NUMBER OF VARIETIES IN 3 MANITOBA NORTHERN WHEAT—EX. VANCOUVER, B.C. FOR PERIOD 1931 TO 1946

| | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | 1939 | 1940 | 1941 | 1943 | 1945 | 1946 | Aver. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of Varieties | 23 | 25 | 24 | 30 | 21 | 19 | 20 | 22 | 15 | 18 | 12 | 21 | 23 | 21 | 21 |

The comparison of the number of varieties in 3 Manitoba Northern Wheat found in Table 4 indicates that apparently there has not been any marked reduction in the average number of varieties found in the cargoes over the fourteen-year period aside from 1939, 1940 and 1941 when only a few cargoes were verified. The average of 21 for the period, however, may be misleading for it will be noted that there were in all some 39 different varieties found in this grade over the next fourteen-year period, while in the higher grade only 34 varieties were identified and 38 in the top grade.

*4 Manitoba Northern Grade Samples*
*Ex Vancouver, B.C.*

Owing to the relatively small number of samples from cargoes of 4 Manitoba Northern wheat shipped from Vancouver which has been supplied for verification, it would be unfair to lay claim to any trends in the percentage of any variety of wheat found, or the number of varieties which make up those cargoes. Only three seasons, 1938, 1943 and 1946, are represented, with a total of only forty-six cargoes for those three seasons. The data in Table A8 in the Appendix, however, are recorded as a matter interest and comparison.

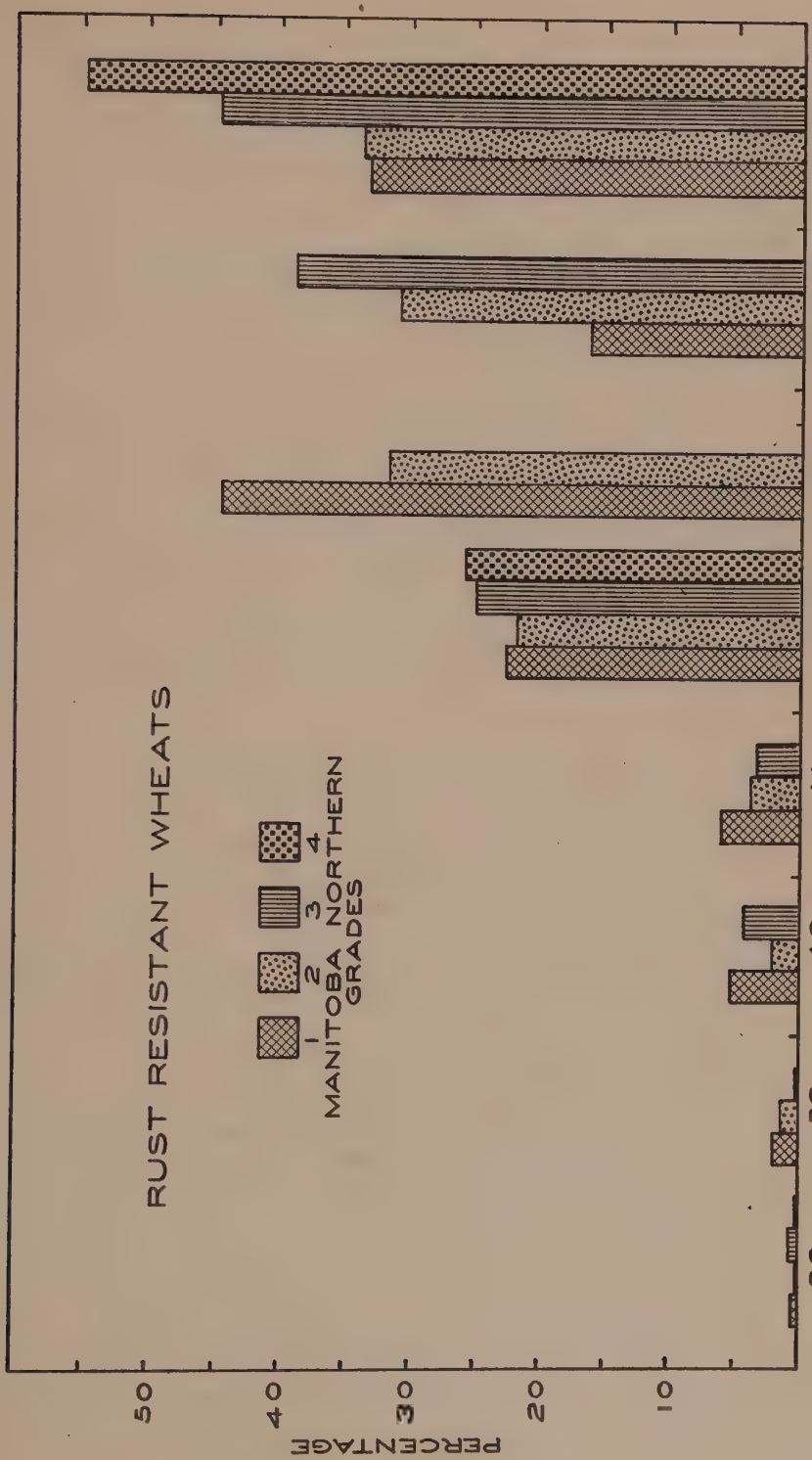


FIGURE 5. Comparison of the percentage of rust-resistant wheats in 1, 2, 3 and 4 Manitoba Northern cargoes. Ex Vancouver, 1938-1946.

Comparing this 4 Manitoba Northern grade with the 3 Manitoba Northern referred to above, it is found that Marquis in the 3 Manitoba Northern Grade was declining in 1938 and reached a low of 3.19 per cent in 1943. In the 4 Northern Grade, however, there was no Marquis found in the two of the 1943 cargoes examined, while Thatcher had increased to such an extent that it comprised over 46 per cent by 1946. The Red Bobs selections declined materially by 1946.

The interesting point to observe in this Grade was the complete elimination of many of the varieties found in the three higher grades. With data obtained from 19 cargoes in 1946 it will be noted that there are only sixteen varieties found compared to 24 in 1938. The 13 found in 1943 are hardly comparable inasmuch as these data were derived from only 2 cargoes in that year.

In 1938, Marquis, Thatcher and Red Bobs made up 73.6 per cent of this grade; in 1943, the average was 1 per cent higher without any Marquis, while in 1946 these same three varieties made up 86 per cent of the grade.

The rust-resistant wheats in the four Grades under consideration out of Vancouver present an interesting comparison and the data indicate that the combined percentages of the four rust-resistant varieties—Thatcher, Apex, Renown and Regent—increased gradually from 1 to 4 Manitoba Northern Grades.

This comparison (Figure 5) indicates the increase in percentage of the rust-resistant wheats in the 1, 2, 3 and 4 Manitoba Northern Grade Cargoes Ex Vancouver.

It should be noted that there were no cargoes in any of the four grades in 1942, and in 3 Manitoba Northern 1944 was missing; while in the 4 Manitoba Northern Grade only three years were represented.

## FORT CHURCHILL, MANITOBA, SAMPLES

Samples from the Port of Fort Churchill were not always sent in for verification, largely because there were comparatively few cargoes moving out of that northern port.

However, between 1935 and 1946 samples from twenty-six cargoes were secured and the data obtained are recorded in the Appendix Table A9.

### *1 Manitoba Northern Grade Samples Ex Churchill, Manitoba, for Period 1935-1946*

This grade of wheat leaving Canada's most northerly port carries a higher Marquis content by a wider margin than either the Fort William or the Vancouver shipments for either comparable years or over the longer period for these other ports.

TABLE 5.—COMPARISON OF MARQUIS CONTENT IN PER CENT IN 1 MANITOBA NORTHERN GRADE FROM THE PORTS OF CHURCHILL, FORT WILLIAM AND VANCOUVER

| Period | Churchill | Fort William | Vancouver |
|---|---|---|---|
| 1935-1946 | 56.6 | 47.2 | 37.2 |
| 1931-1946 | — | 37.2 | 32.3 |

The Garnet content on the average is very similar to that of the Fort William and Vancouver shipments for the same years. The Thatcher content is much higher in the 1938 cargoes than the Fort William, but less than the Fort William cargoes in 1939 and 1946.

In 1937, 1938 and 1939, the Red Bobs content did not conform to the content of this grade from either of the other ports. This can be explained by the fact that cars of wheat drawn for inspection, passing through the Port of Churchill, come from the northern part of Saskatchewan where Red Bobs is not grown to any extent.

The 11 to 15 per cent made up of Early Red Fife and Type IC in 1935, 1936 and 1937 has been replaced by Thatcher in 1938 and 1939 when the interest in the importance of Thatcher became established. A comparison of the percentage of Marquis, Reward, Red Bobs, Early Red Fife and Type IC wheat varieties will be dealt with after discussing the 2 and 3 Manitoba Northern Grades from this port.

These Churchill shipments present an entirely different aspect to the varietal picture than can be found in those from Fort William and Vancouver. While the number of cargoes examined from Churchill in any one year is relatively small compared to the two latter ports, nevertheless it is interesting to note the trend in varieties based on those data. In 1935, at least traces of nearly every variety listed were found, while by 1946 only those in the upper two-thirds of the list were found, many of these in Trace proportions, with 71 per cent made up entirely of rust-resistant varieties.

*2 Manitoba Northern Grade Samples*
*Ex Churchill, Manitoba*

The Table No. A10 in the Appendix provides data for this group of samples and it will be noted that the 2 Manitoba Northern Grade cargoes shipped out of the Port of Churchill, represented by only thirty-four samples, vary quite widely in the percentage of Marquis found from year to year, which, for the years 1935 to 1939 ranged from 35.7 to 66.0 per cent. This range was relatively narrower than was the case in the Fort William cargoes, but wider than the Vancouver cargoes for the same years. The percentage of Marquis found in 1943, however, was lower than either of the other ports of shipments. The Thatcher content in this grade increased more rapidly than in either the 1 or 3 Manitoba Northern grades, and by 1943, became the dominating variety in this Grade. The other varieties made much the same contribution to the cargoes as in similar grades from the other ports, Red Bobs making a sudden upward swing in 1938, but dropping off by 2 per cent in each of the years 1939, 1943 and 1946. The rust-resistant varieties, aside from Thatcher, were not heavy contributors to this grade.

The 3 Manitoba Northern Grade, data on which will be found in Table A-1, represented by nineteen cargoes, contained a higher and more uniform Marquis content for the 1935 and 1939 period than was found in similar grades from the other ports. In the years 1940, 1941, when no samples were supplied, the rust-resistant varieties—Thatcher, Apex, Renown and Regent—made great headway so that, from 1943 to 1946, these four rust-resistant varieties increased from 62.3 per cent to 93.6 per

cent in the cargoes. The Red Bobs selections, along with Early Red Fife and Type IC, have never been heavy contributors to this grade and reached a new low in 1946.

The number of varieties making up this grade never was high but in 1946, on the data derived from 2 cargoes, an all-time low of eight varieties was reached. The varieties making up these 1946 shipments are those mainly responsible for the bulk of this grade in previous years and Table 6 is made up principally from these same varieties.

TABLE 6.—COMPARISON OF COMBINED PERCENTAGES OF MARQUIS, REWARD, RED BOBS, EARLY RED FIFE, TYPE IC AND THE FOUR RUST-RESISTANT WHEATS, THATCHER, APEX, REGENT AND RENOWN, SHIPPED FROM CHURCHILL, MANITOBA, 1935*-1946

| Grade | 1935 | 1936 | 1937 | 1938 | 1939 | 1943 | 1946 | Average 1935-1939 | Average 1935-1946 |
|---|---|---|---|---|---|---|---|---|---|
| 1 Man. Nor. | 88.1 | 94.6 | 84.6 | 97.4 | 94.3 | — | 98.3 | 91.8 | 92.9 |
| 2 Man. Nor. | 80.5 | 89.3 | 70.0 | 93.0 | 92.5 | 94.4 | 98.0 | 85.1 | 88.2 |
| 3 Man. Nor. | 63.7 | 59.6 | 45.0 | 78.2 | 87.6 | 88.4 | 98.3 | 66.8 | 74.4 |

* 1940, 1941, 1942, 1944, 1945 not represented.

The data in Table 6 indicate that for the years under consideration, 1935-1946, the combined percentages of certain wheats varied with the grade from year to year but that the percentages in the lower grades rose steadily so that by 1946 all these grades had practically reached the same high level of 98 per cent.

## CARGOES LEAVING PORT OF MONTREAL

The one year in which cargo samples were obtained from this port covered the 1935 crop season and, as the number of samples was representative, the data for that year can be compared without any reservations. In Table A12 in the Appendix, it will be noted that the percentage of Marquis was well maintained in all grades, although lower than those from the Port of Fort William for the same grades and year. The Garnet

TABLE 7.—COMPARISON OF THE NUMBER OF WHEAT VARIETIES ENTERING 1, 2 AND 3 MANITOBA NORTHERN GRADES FROM THE PORTS OF FORT WILLIAM, VANCOUVER AND MONTREAL FOR YEARS 1931-1946

| | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | 1939 | 1940 | 1941 | 1943 | 1944 | 1945 | 1946 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1° | | | | | | | | | | | | | | | |
| Fort William | 20 | 26 | 26 | 28 | 22 | 22 | 24 | 24 | 16 | 22 | 21 | 20 | 20 | 17 | 15 |
| Vancouver | 24 | 23 | 27 | 28 | 22 | 21 | 22 | 24 | 13 | 16 | 17 | 24 | 18 | 19 | 21 |
| Churchill | — | — | — | — | 20 | 18 | 12 | 14 | 11 | — | — | — | — | — | 16 |
| Montreal | — | — | — | — | 23 | — | — | — | — | — | — | — | — | — | — |
| 2° | | | | | | | | | | | | | | | |
| Fort William | 23 | 26 | 25 | 25 | 23 | 23 | 24 | 23 | 21 | 24 | 21 | 21 | 21 | 17 | 17 |
| Vancouver | 21 | 25 | 25 | 27 | 21 | 21 | 25 | 23 | 18 | 16 | 11 | 23 | 17 | 22 | 25 |
| Churchill | — | — | — | — | 18 | 18 | 16 | 14 | 17 | — | — | 20 | — | — | 17 |
| Montreal | — | — | — | — | 20 | — | — | — | — | — | — | — | — | — | — |
| 3° | | | | | | | | | | | | | | | |
| Fort William | 27 | 26 | 25 | 25 | 25 | 18 | 23 | 25 | 19 | 23 | 19 | 19 | 19 | 21 | 16 |
| Vancouver | 23 | 25 | 24 | 30 | 21 | 19 | 20 | 22 | 15 | 18 | 12 | 21 | — | 21 | 21 |
| Churchill | — | — | — | — | 13 | 15 | 14 | 13 | 13 | — | — | 18 | — | — | 8 |
| Montreal | — | — | — | — | 24 | — | — | — | — | — | — | — | — | — | — |

content was relatively high in the 3 Manitoba Northern Grade but it must be remembered that Garnet was not graded separately till the year 1937. Reward content remained high for this variety and Type IC was uniform across the three grades. The number of varieties making up each grade was fairly uniform, considering that the 2 Manitoba Northern Grade was composed of only four varieties.

The data in Table 7 clearly indicate that the introduction of new varieties in recent years has tended to gradually reduce the number of varieties found in the Overseas Cargoes; whereas the 20-27 varieties found in the 1931 cargoes were all of a stem rust susceptible nature. Four of those making up the 1946 samples were rust-resistant varieties whose quality is beyond question. These four new varieties now comprise a very substantial percentage of the cargoes, even in the case of the 2 Manitoba Northern Grade from Vancouver in 1946, where there was no apparent decrease in the number of varieties, as six of the less desirable varieties have been eliminated. The early criticism that Canadian export wheat was deteriorating is therefore not justified with the current list of wheats entering into the Overseas cargoes.

## SUMMARY AND CONCLUSIONS

In 1925 fear was entertained by certain persons that the reputation of Canadian export wheat was in danger because of the high percentage of varieties of mediocre quality which it was believed were being grown at that time. In order to obtain factual information on this point, the Cereal Division, Department of Agriculture, Ottawa, in co-operation with the Board of Grain Commissioners, conducted exacting investigations extending over a twenty-three year period. During this period actual growing tests were made at Ottawa of two thousand, eight hundred and seventy-five samples collected by the Board of Grain Commissioners from this number of cargoes actually shipped from Pacific and Eastern Ports.

The data presented indicate clearly that at no time during the period under investigation was the percentage of undesirable varieties sufficiently great to have any possible effect on the general quality of our wheat.

While it is true that the number of undesirable varieties grown at one time was possibly greater than one would wish, yet the actual percentage of these was never very high. To-day, most of these varieties are practically extinct.

## ACKNOWLEDGMENTS

The writer of this paper wishes to express his sincere thanks to L. H. Newman for the assistance so freely given, and the helpful criticisms offered by various members of the Cereal Division Staff and the others with whom this report has been discussed. The writer also wishes to pay tribute to W. H. Brown, F. B. McNaughton, F. Gfeller, G. Ballantine and others for the technical assistance in verifying the samples over the period of years.

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## APPENDIX

TABLE A1.—VARIETAL COMPOSITION OF 1 MANITOBA NORTHERN WHEAT BASED ON 455 CARGOES. EX. FORT WILLIAM, ONT. FOR YEARS 1931-1946, INCLUSIVE IN PER CENT

| | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | 1939 | 1940 | 1941 | 1943 | 1944 | 1945 | 1946 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marquis | 69.8 | 66.52 | 68.34 | 61.99 | 73.55 | 71.22 | 44.49 | 55.55 | 36.17 | 12.20 | 12.64 | 5.87 | 3.79 | 5.00 | 1.89 |
| Garnet | 2.4 | 1.67 | 2.93 | 2.41 | 1.33 | 0.46 | 1.14 | 0.26 | 0.13 | 0.28 | 0.22 | 0.09 | 0.03 | 0.08 | 0.02 |
| Reward | 6.7 | 8.59 | 10.32 | 8.13 | 6.07 | 10.85 | 12.38 | 2.57 | 1.49 | 1.52 | 1.04 | 1.05 | 0.46 | 0.13 | 0.16 |
| Thatcher | — | — | — | — | — | — | 0.23 | 11.48 | 38.47 | 37.91 | 39.67 | 49.70 | 68.73 | 80.22 | 74.21 |
| Apex | — | — | — | — | — | — | — | — | 0.35 | 20.61 | 17.47 | 14.15 | 9.72 | 2.02 | 2.13 |
| Renown | — | — | — | — | — | — | — | — | 2.58 | 3.10 | 5.32 | 5.45 | 2.54 | 1.28 | 1.48 |
| Regent | — | — | — | — | — | — | — | — | — | 0.77 | 3.54 | 8.16 | 3.71 | 1.37 | 19.06 |
| Red Fife | 2.2 | 3.07 | 0.34 | 0.91 | 0.08 | 1.25 | 4.60 | 0.39 | — | 0.07 | 0.45 | 0.24 | 0.03 | — | — |
| Ruby | 0.7 | 0.22 | 0.07 | 1.35 | 0.48 | 0.36 | 0.07 | 0.25 | — | 0.12 | 0.02 | — | — | — | — |
| Red Bobs Sel. | 2.1 | 2.12 | 3.00 | 2.89 | 1.79 | 1.51 | 26.46 | 20.83 | 14.93 | 16.64 | 13.50 | 10.75 | 5.75 | 7.25 | 0.15 |
| Ceres | 2.6 | 3.06 | 3.45 | 8.17 | 1.78 | 4.24 | 1.87 | 1.08 | 1.24 | 1.07 | 0.74 | 0.62 | 0.49 | 0.83 | 0.06 |
| Early Red Fife | 1.8 | 1.78 | 1.06 | 1.53 | 0.76 | 0.56 | 0.88 | 0.10 | 0.30 | 0.81 | 0.43 | 0.18 | 0.11 | 0.09 | — |
| Type IC | 8.0 | 6.79 | 5.86 | 5.63 | 7.57 | 6.29 | 3.84 | 4.44 | 3.21 | 3.57 | 2.74 | 1.88 | 1.26 | 1.07 | 0.20 |
| Reliance | — | — | — | — | — | — | 0.29 | — | — | 0.24 | 0.02 | — | 0.05 | 0.06 | — |
| Canus | — | — | — | — | — | — | — | 0.03 | — | 0.12 | 0.18 | — | 0.13 | — | — |
| Kota | 1.8 | 2.06 | 1.57 | 3.02 | 1.47 | 2.19 | 0.78 | 0.64 | 0.54 | 0.14 | 0.80 | 0.38 | 0.20 | 0.21 | 0.04 |
| Pioneer | — | 0.32 | 0.55 | 0.19 | 0.14 | — | 0.05 | — | — | — | — | — | — | — | — |
| Coronation | — | — | — | — | — | — | — | 0.03 | — | 0.06 | 0.12 | 0.44 | 0.30 | — | — |
| Renfrew | 0.10 | 0.11 | 0.06 | 0.10 | 0.01 | 0.02 | 0.02 | 0.03 | — | — | — | — | — | — | — |
| Kitchener | 0.33 | 0.10 | 0.10 | 0.02 | — | 0.03 | 0.02 | — | — | — | — | — | — | — | — |
| Huron | 0.37 | 0.01 | 0.01 | 0.53 | 0.10 | 0.03 | 0.08 | 0.03 | — | — | — | — | — | — | — |
| Preston | 0.03 | 0.17 | 0.29 | 0.10 | — | 0.11 | 0.08 | 0.03 | — | — | — | 0.02 | — | — | — |
| Stanley | — | 0.67 | 0.36 | 0.70 | 0.34 | 0.24 | 0.05 | 0.04 | 0.04 | — | — | 0.03 | — | — | — |
| Parkers Sel. | 0.16 | 0.36 | 0.21 | 1.19 | 0.83 | 0.16 | 0.10 | 0.54 | 0.01 | 0.04 | 0.02 | — | — | 0.02 | — |
| Fishers Sel. | — | 0.11 | 0.03 | 0.14 | — | 0.02 | — | — | — | — | — | 0.02 | — | — | 0.02 |
| Prelude | — | 0.01 | 0.05 | — | 0.03 | — | 0.03 | — | — | — | — | — | — | — | — |
| Miscellaneous | 0.28 | 0.46 | 0.40 | 0.01 | 1.70 | 0.14 | 1.93 | 0.87 | 0.17 | 0.36 | 0.12 | 0.82 | 2.61 | 0.13 | — |
| Quality | — | — | 0.05 | 0.07 | — | — | — | — | — | — | — | — | — | — | — |
| Axminster | — | — | — | 0.01 | — | — | — | — | — | — | — | — | — | — | — |
| Ladoga | — | 0.12 | 0.61 | 0.78 | 0.11 | — | 0.49 | 0.47 | 0.15 | 0.18 | 0.08 | 0.03 | — | — | 0.02 |
| White Russian | 0.03 | 0.15 | 0.02 | 0.08 | 0.11 | 0.08 | 0.02 | 0.01 | — | 0.04 | — | — | 0.01 | 0.02 | 0.02 |
| Early Russian | — | 0.15 | — | 0.13 | 0.03 | 0.03 | — | — | — | — | — | — | — | — | — |
| Vermilion | — | — | — | 0.02 | — | — | — | — | — | — | — | — | 0.01 | — | — |
| Club or Red Club | 0.09 | 0.04 | 0.04 | 0.03 | 0.02 | — | — | 0.01 | 0.04 | 0.04 | — | — | — | — | — |
| Speltoid | 0.45 | 0.05 | 0.06 | 0.08 | 0.02 | 0.11 | 0.05 | 0.07 | — | — | 0.02 | 0.02 | 0.03 | 0.04 | — |
| Durum | 0.03 | 0.01 | 0.02 | 0.03 | — | 0.03 | — | 0.04 | — | — | — | — | — | — | 0.11 |
| Rye | — | — | — | — | — | — | — | 0.03 | — | — | — | — | — | — | — |
| 6 Row barley | — | — | 0.04 | 0.05 | 0.02 | 0.05 | 0.03 | 0.01 | 0.04 | 0.06 | — | — | 0.03 | 0.13 | 0.06 |
| 2 Row barley | — | — | 0.05 | 0.01 | — | 0.01 | — | — | 0.02 | 0.02 | — | — | — | 0.02 | — |
| Tame oats | — | 0.01 | 0.02 | 0.03 | — | — | — | 0.01 | 0.13 | 0.02 | — | — | — | — | — |
| Wild oats | 0.01 | 0.03 | 0.03 | 0.03 | — | — | — | — | — | — | — | — | 0.01 | 0.02 | — |
| Number of cargoes | 30 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |

TABLE A2.—VARIETAL COMPOSITION OF 2 MANITOBA NORTHERN WHEAT BASED ON 456 CARGOES. EX. FORT WILLIAM, ONT. FOR YEARS 1931-1946, INCLUSIVE IN PER CENT

| | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | 1939 | 1940 | 1941 | 1943 | 1944 | 1945 | 1946 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marquis | 40.93 | 41.18 | 44.63 | 40.02 | 72.22 | 55.62 | 34.34 | 44.03 | 25.94 | 9.50 | 10.42 | 2.95 | 0.22 | 4.92 | 2.24 |
| Garnet | 33.52 | 33.00 | 33.49 | 37.64 | 1.22 | 1.77 | 1.84 | 0.54 | 0.47 | 0.56 | 0.25 | 0.05 | 0.08 | 0.10 | 0.07 |
| Reward | 4.00 | 6.33 | 7.74 | 6.68 | 4.92 | 15.16 | 16.95 | 6.02 | 2.04 | 1.49 | 0.94 | 0.55 | 0.35 | 0.45 | 0.07 |
| Thatcher | — | — | — | — | — | — | 1.15 | 25.44 | 53.72 | 49.21 | 48.81 | 64.37 | 70.75 | 76.29 | 76.21 |
| Apex | — | — | — | — | — | — | — | — | 0.39 | 7.66 | 7.13 | 10.58 | 7.50 | 4.38 | 1.83 |
| Renown | — | — | — | — | — | — | — | — | 6.38 | 6.74 | 4.32 | 5.92 | 3.03 | 1.86 | 0.59 |
| Regent | — | — | — | — | — | — | — | — | — | 3.42 | 7.38 | 8.00 | 7.83 | 2.51 | 17.82 |
| Red Fife | 2.58 | 2.74 | 0.45 | 0.48 | 0.30 | 1.20 | 4.50 | 0.43 | 0.02 | — | 0.06 | 0.15 | — | — | — |
| Ruby | 0.92 | 0.31 | 0.10 | 0.35 | 0.47 | 0.41 | 0.10 | 0.16 | — | 0.01 | — | 0.01 | 0.01 | — | — |
| Red Bobs Sel. | 2.28 | 1.95 | 2.78 | 2.35 | 1.44 | 6.56 | 24.38 | 14.71 | 7.28 | 17.10 | 17.42 | 5.30 | 5.97 | 7.00 | 0.31 |
| Ceres | 2.57 | 2.37 | 2.16 | 1.78 | 1.74 | 7.67 | 5.58 | 1.14 | 1.05 | 0.71 | 0.33 | 0.66 | 0.50 | 0.60 | 0.17 |
| Early Red Fife | 3.08 | 1.40 | 0.56 | 0.90 | 1.78 | 0.46 | 1.21 | 0.52 | 0.19 | 0.34 | 0.46 | 0.06 | 0.06 | 0.08 | — |
| Type IC | 4.29 | 3.90 | 3.42 | 4.44 | 10.75 | 5.75 | 3.05 | 3.63 | 1.48 | 1.53 | 1.71 | 0.53 | 0.43 | 0.89 | 0.17 |
| Reliance | — | — | — | — | — | — | — | 0.04 | 0.02 | 0.28 | 0.06 | 0.03 | 0.02 | 0.08 | — |
| Canus | — | — | — | — | — | — | 0.70 | — | — | 0.15 | 0.06 | — | 0.02 | — | 0.02 |
| Kota | 1.09 | 1.76 | 1.46 | 1.27 | 1.75 | 3.55 | 1.61 | 0.82 | 0.39 | 0.11 | 0.31 | 0.24 | 0.03 | 0.05 | — |
| Pioneer | — | 0.64 | 3.42 | 0.12 | 0.07 | 0.04 | — | — | — | — | — | — | — | — | 0.08 |
| Coronation | — | — | — | — | — | — | — | 0.03 | 0.09 | 0.01 | 0.13 | 0.04 | 0.50 | — | — |
| Renfrew | 0.88 | 0.79 | 0.25 | 0.08 | 0.06 | 0.04 | — | 0.04 | — | — | — | — | — | — | — |
| Kitchener | 0.24 | 0.15 | 0.04 | 0.01 | 0.16 | — | 0.04 | — | — | — | — | — | — | — | 0.02 |
| Huron | 0.90 | 0.03 | 0.04 | 0.53 | 0.24 | 0.06 | 0.12 | 0.09 | 0.02 | — | — | — | — | — | — |
| Preston | 0.04 | 0.49 | 0.27 | 0.03 | 0.03 | 0.26 | 0.26 | 0.03 | — | 0.17 | 0.04 | — | — | — | — |
| Stanley | 0.41 | 1.09 | 0.50 | 0.88 | 0.30 | 0.31 | 0.12 | 0.16 | 0.04 | 0.03 | — | 0.06 | 0.03 | 0.01 | — |
| Parkers Sel. | 0.39 | 0.23 | 0.47 | 1.25 | 1.19 | 0.39 | 0.20 | 0.70 | 0.02 | 0.11 | — | 0.03 | — | — | 0.02 |
| Fishers Sel. | — | 0.14 | — | 0.13 | — | 0.07 | — | — | 0.02 | — | — | — | — | — | — |
| Prelude | — | — | 0.03 | 0.03 | — | 0.04 | — | — | — | — | — | — | — | — | — |
| Miscellaneous | 1.01 | 0.45 | 0.15 | — | 0.78 | 0.13 | 3.10 | 0.46 | 0.11 | 0.36 | — | 0.32 | 1.52 | 0.20 | — |
| Quality | 0.05 | 0.01 | 0.01 | — | — | — | — | — | — | — | — | — | — | — | — |
| Axminster | — | — | — | 0.01 | — | — | — | — | — | — | — | — | — | — | — |
| Ladoga | — | 0.61 | 0.38 | 0.33 | 0.34 | — | 0.41 | 0.36 | 0.09 | 0.17 | 0.06 | — | — | 0.03 | 0.10 |
| White Russian | 0.22 | 0.13 | 0.03 | 0.24 | 0.04 | 0.04 | 0.04 | — | — | 0.06 | 0.02 | — | 0.01 | 0.01 | — |
| Early Russian | — | 0.05 | 0.03 | 0.12 | 0.03 | 0.02 | 0.02 | 0.03 | — | — | — | — | — | — | 0.02 |
| Vermilion | 0.01 | — | — | 0.05 | — | — | — | — | — | — | — | — | — | — | — |
| Club or Red Club | 0.10 | 0.09 | 0.16 | 0.07 | 0.01 | — | 0.04 | — | — | 0.06 | 0.02 | — | — | — | — |
| Speltoid | 0.22 | 0.07 | 0.02 | 0.04 | 0.01 | 0.20 | 0.05 | 0.06 | 0.04 | 0.02 | 0.02 | 0.32 | 0.08 | — | — |
| Durum | 0.01 | 0.04 | — | — | — | 0.06 | 0.04 | 0.07 | — | — | — | 0.02 | 0.01 | — | 0.07 |
| Rye | — | — | — | — | — | — | — | — | — | 0.02 | — | — | — | — | 0.02 |
| 6 Row Barley | 0.01 | 0.11 | 0.05 | 0.09 | 0.04 | 0.15 | 0.11 | 0.01 | 0.06 | 0.04 | 0.02 | — | 0.03 | 0.30 | 0.12 |
| 2 Row Barley | — | — | 0.05 | — | 0.04 | 0.04 | 0.02 | — | 0.02 | 0.02 | — | 0.01 | — | 0.07 | — |
| Tame oats | — | — | 0.04 | 0.08 | 0.03 | 0.02 | — | 0.01 | 0.11 | 0.06 | 0.02 | — | — | — | — |
| Wild oats | — | 0.01 | 0.01 | 0.01 | — | — | — | — | — | 0.02 | — | — | — | 0.07 | — |
| Number of cargoes | 31 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |

TABLE A3.—VARIETAL COMPOSITION OF 3 MANITOBA NORTHERN WHEAT BASED ON 454 CARGOES. EX. FORT WILLIAM, ONT. FOR YEARS 1931-1946, INCLUSIVE IN PER CENT

| | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | 1939 | 1940 | 1941 | 1943 | 1944 | 1945 | 1946 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marquis | 38.88 | 42.36 | 51.34 | 33.91 | 53.48 | 23.61 | 7.45 | 37.50 | 23.21 | 6.06 | 6.66 | 1.43 | 0.27 | 3.25 | 3.51 |
| Garnet | 25.01 | 27.02 | 22.55 | 38.97 | 24.13 | 58.31 | 70.75 | 1.60 | 0.70 | 1.18 | 0.48 | 0.07 | 0.23 | 0.43 | 0.06 |
| Reward | 3.59 | 8.64 | 6.80 | 8.77 | 5.82 | 5.93 | 4.64 | 6.41 | 2.27 | 1.65 | 0.50 | 0.41 | 0.50 | 0.53 | 0.05 |
| Thatcher | — | — | — | — | — | — | 0.21 | 22.12 | 45.88 | 54.76 | 58.86 | 72.44 | 51.73 | 64.37 | 82.65 |
| Apex | — | — | — | — | — | — | — | — | 0.45 | 5.18 | 10.45 | 9.06 | 11.89 | 11.33 | 1.93 |
| Renown | — | — | — | — | — | — | — | — | 5.22 | 5.54 | 3.41 | 3.95 | 4.43 | 3.11 | 0.79 |
| Regent | — | — | — | — | — | — | — | — | — | 2.95 | 6.79 | 5.78 | 6.43 | 3.82 | 7.58 |
| Red Fife | 3.90 | 1.09 | 0.68 | 0.60 | 0.55 | 0.74 | 0.21 | 0.95 | — | 0.19 | 0.02 | 0.02 | 0.04 | 0.01 | — |
| Ruby | 2.94 | 0.33 | 0.03 | 0.83 | 0.12 | 0.45 | 0.42 | 0.11 | 0.06 | 0.02 | — | 0.05 | — | 0.14 | — |
| Red Bobs Sel. | 4.13 | 3.34 | 2.79 | 4.13 | 1.66 | 3.21 | 8.16 | 21.05 | 18.31 | 19.01 | 10.97 | 3.86 | 21.26 | 9.95 | 1.14 |
| Ceres | 2.92 | 5.74 | 3.66 | 1.62 | 1.75 | 1.69 | 1.70 | 2.42 | 0.52 | 0.64 | 0.13 | 0.88 | 0.46 | 0.65 | 0.54 |
| Early Red Fife | 2.18 | 0.69 | 1.34 | 1.04 | 1.44 | 0.62 | 0.13 | 0.72 | 0.27 | 0.51 | 0.46 | 0.18 | 0.18 | 0.08 | 0.03 |
| Type IC | 5.40 | 3.45 | 6.46 | 5.34 | 6.80 | 3.12 | 0.87 | 3.18 | 1.10 | 0.96 | 0.46 | 0.85 | 1.10 | 0.91 | 0.74 |
| Reliance | — | — | — | — | — | — | 0.03 | — | — | 0.15 | 0.04 | 0.02 | — | 0.07 | 0.02 |
| Canus | — | — | — | — | — | — | — | — | — | — | 0.08 | — | — | — | — |
| Kota | 0.92 | 0.306 | 2.42 | 1.00 | 0.95 | 1.13 | 0.95 | 0.70 | 0.68 | 0.10 | 0.15 | 0.12 | 0.03 | 0.05 | 0.06 |
| Pioneer | 0.61 | 0.19 | 0.63 | 0.23 | 0.06 | 0.10 | 0.23 | — | — | 0.06 | — | — | — | — | — |
| Coronation | — | — | — | — | — | — | — | 0.40 | 0.64 | 0.06 | 0.36 | 0.02 | 0.93 | 0.01 | 0.09 |
| Renfrew | 0.97 | 0.65 | 0.06 | 0.04 | 0.04 | — | — | 0.10 | — | — | — | — | — | — | — |
| Kitchener | 0.95 | 0.05 | 0.19 | 0.01 | 0.06 | — | — | — | — | — | — | — | — | — | — |
| Huron | 0.80 | 0.11 | 0.13 | 0.34 | 0.12 | — | 0.19 | 0.11 | 0.04 | 0.04 | — | 0.02 | — | — | — |
| Preston | 0.07 | 0.40 | 0.77 | 0.12 | 0.07 | 0.26 | 0.06 | 0.19 | — | 0.13 | 0.04 | — | 0.01 | — | — |
| Stanley | 1.13 | 0.75 | 0.07 | 0.53 | 0.22 | 0.24 | 0.30 | 0.14 | 0.14 | 0.09 | — | — | — | — | — |
| Parkers Sel. | 1.72 | 0.44 | 0.01 | 1.59 | 1.51 | 0.21 | 0.13 | 0.65 | — | — | — | — | — | — | — |
| Quality | 0.23 | — | 0.30 | — | — | — | — | — | — | — | — | — | — | — | — |
| Prelude | — | 0.01 | 0.03 | 0.03 | 0.03 | — | 0.03 | 0.01 | — | — | — | — | — | — | — |
| Fishers | 0.06 | 0.06 | — | 0.05 | 0.01 | — | — | 0.02 | — | — | — | — | — | — | — |
| Miscellaneous | 1.56 | 0.42 | 0.10 | — | 0.38 | 0.12 | 3.22 | 0.62 | 0.14 | 0.28 | 0.04 | 0.71 | 0.27 | 0.63 | — |
| Ladoga | 0.05 | 0.60 | 0.28 | 0.54 | 0.50 | — | 0.02 | 0.41 | 0.16 | 0.04 | — | — | — | 0.10 | 0.02 |
| White Russian | 1.00 | 0.11 | 0.03 | 0.09 | 0.07 | — | — | 0.04 | — | 0.10 | — | — | — | — | — |
| Early Russian | 0.33 | 0.04 | — | 0.04 | 0.03 | — | — | — | — | — | — | — | — | — | — |
| Java | 0.07 | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Broatch Sel. | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.01 | — |
| Club or Red Club | 0.05 | 0.04 | 0.06 | 0.05 | — | 0.02 | 0.02 | 0.01 | — | — | — | — | 0.01 | — | — |
| Marquillo | — | — | — | — | — | 0.05 | — | — | — | — | — | — | — | — | — |
| Speltoid | 0.39 | 0.13 | 0.01 | 0.02 | 0.03 | 0.06 | 0.05 | 0.07 | 0.04 | 0.09 | 0.02 | 0.02 | 0.07 | 0.05 | — |
| Durum | 0.05 | 0.06 | 0.14 | 0.03 | 0.03 | — | 0.03 | 0.03 | 0.06 | — | — | — | 0.03 | 0.03 | 0.08 |
| Rye | — | — | — | — | — | — | 0.17 | — | 0.02 | — | — | — | — | 0.07 | — |
| 6 Row barley | 0.02 | 0.14 | 0.09 | 0.08 | 0.03 | 0.05 | 0.02 | 0.02 | 0.04 | 0.09 | 0.04 | 0.08 | 0.01 | 0.29 | 0.11 |
| 2 Row barley | 0.02 | 0.01 | 0.01 | — | — | 0.02 | — | — | 0.02 | 0.02 | — | 0.02 | 0.01 | 0.01 | 0.06 |
| Tame oats | — | 0.02 | 0.04 | 0.01 | — | 0.02 | — | — | 0.02 | 0.06 | 0.02 | — | — | — | — |
| Wild oats | 0.02 | — | 0.01 | 0.01 | — | 0.03 | — | 0.01 | — | — | — | — | 0.01 | — | — |
| Number of cargoes | 31 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |

TABLE A4.—VARIETAL COMPOSITION OF 4 MANITOBA NORTHERN WHEAT BASED ON 177 CARGOES. EX. FORT WILLIAM, ONT. FOR YEARS 1938-1946, INCLUSIVE IN PER CENT

| | 1938 | 1939 | 1940 | 1941 | 1943 | 1944 | 1945 | 1946 |
|---|---|---|---|---|---|---|---|---|
| Marquis | 55.22 | 53.83 | 20.31 | 2.97 | 6.06 | 0.04 | 11.55 | 4.75 |
| Garnet | 3.70 | 1.65 | 3.53 | 0.68 | 2.15 | 0.58 | 0.63 | 0.17 |
| Reward | 8.22 | 1.54 | 3.22 | 0.37 | 0.68 | 0.47 | 0.62 | — |
| Thatcher | 7.77 | 20.76 | 40.46 | 62.54 | 44.56 | 48.72 | 65.36 | 80.75 |
| Apex | — | — | — | 11.55 | 9.58 | 13.34 | 1.41 | 1.96 |
| Renown | — | — | 2.44 | 4.58 | 4.10 | 3.00 | 2.56 | 0.64 |
| Regent | — | — | 0.57 | 8.61 | 5.31 | 9.35 | 3.90 | 5.23 |
| Red Fife | 0.76 | 0.06 | 0.04 | 0.05 | — | — | 0.02 | — |
| Ruby | 0.10 | — | 0.13 | — | 0.02 | — | — | 0.05 |
| Red Bobs Sel. | 10.41 | 17.32 | 23.76 | 6.90 | 21.42 | 22.05 | 9.36 | 3.75 |
| Ceres | 5.78 | 0.53 | 0.57 | 0.45 | 0.45 | 0.57 | 0.88 | 0.31 |
| Early Red Fife | 0.59 | 0.20 | 0.52 | 0.08 | 0.19 | 0.27 | 0.10 | 0.02 |
| Type IC | 3.91 | 1.54 | 1.83 | 0.39 | 1.83 | 0.74 | 0.87 | 1.15 |
| Reliance | 0.05 | 0.04 | 0.48 | — | 0.02 | — | 0.03 | — |
| Canus | — | — | — | — | 0.06 | 0.02 | — | — |
| Kota | 1.17 | 0.94 | 0.08 | 0.03 | 0.15 | 0.08 | 0.07 | 0.09 |
| Pioneer | — | — | 0.13 | — | 0.02 | — | — | — |
| Coronation | — | — | 0.04 | 0.39 | 0.47 | 0.20 | — | 0.29 |
| Renfrew | 0.06 | — | — | — | — | — | — | — |
| Huron | 0.03 | 0.07 | — | — | 0.04 | 0.02 | 0.05 | — |
| Preston | 0.12 | 0.11 | — | 0.05 | — | 0.02 | — | 0.03 |
| Stanley | 0.10 | — | 0.17 | 0.10 | 0.04 | — | — | — |
| Parkers Sel. | 0.54 | — | — | — | 0.04 | — | 0.02 | — |
| Prelude | — | — | 0.04 | — | — | — | — | — |
| Miscellaneous | 0.52 | 0.55 | 0.83 | 0.03 | 2.49 | 0.18 | 2.17 | — |
| Ladoga | 0.47 | — | — | 0.03 | 0.02 | 0.04 | — | 0.10 |
| White Russian | 0.06 | — | 0.35 | — | 0.02 | — | 0.01 | — |
| Club or Red Club | 0.03 | 0.02 | — | — | — | — | — | — |
| Speltoid | 0.07 | — | — | 0.03 | 0.02 | 0.10 | 0.08 | — |
| Durum | 0.05 | 0.29 | 0.04 | 0.03 | 0.02 | 0.06 | — | 0.07 |
| Rye | 0.01 | 0.02 | — | 0.03 | 0.04 | — | — | 0.02 |
| 6 Row barley | 0.03 | 0.08 | 0.26 | 0.03 | 0.13 | 0.12 | 0.25 | 0.07 |
| 2 Row barley | — | — | 0.09 | 0.03 | 0.02 | — | 0.02 | 0.09 |
| Tame oats | 0.01 | 0.21 | — | 0.05 | — | — | — | — |
| Wild oats | 0.01 | — | — | — | — | — | — | — |
| Number of cargoes | 25 | 22 | 11 | 20 | 25 | 25 | 25 | 24 |

TABLE A5.—VARIETAL COMPOSITION OF 1 MANITOBA NORTHERN WHEAT BASED ON 404 CARGOES. EX. VANCOUVER, B.C. FOR THE YEARS 1931-1946, INCLUSIVE IN PER CENT

| | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | 1939 | 1940 | 1941 | 1943 | 1944 | 1945 | 1946 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marquis | 49.72 | 51.60 | 53.78 | 53.75 | 54.09 | 51.32 | 44.36 | 31.81 | 32.65 | 13.73 | 15.64 | 3.69 | 0.29 | 19.22 | 8.99 |
| Garnet | 3.83 | 4.26 | 2.87 | 2.73 | 1.11 | 1.05 | 1.17 | 0.86 | 0.93 | 1.17 | 1.25 | 0.67 | 0.19 | 0.46 | 0.64 |
| Reward | 4.38 | 9.58 | 10.72 | 6.05 | 4.47 | 3.46 | 2.49 | 1.64 | 2.43 | 2.38 | 3.01 | 2.26 | 2.26 | 1.07 | 0.23 |
| Thatcher | — | — | — | — | — | — | 0.11 | 0.44 | 1.90 | 5.21 | 5.86 | 8.56 | 22.34 | 15.10 | 27.90 |
| Apex | — | — | — | — | — | — | — | — | — | — | 0.11 | 8.64 | 16.14 | 0.04 | 1.98 |
| Renown | — | — | — | — | — | — | — | — | — | — | 0.06 | 3.25 | 1.08 | 0.32 | 0.43 |
| Regent | — | — | — | — | — | — | — | — | — | — | — | 2.60 | 5.31 | 1.25 | 3.17 |
| Red Fife | 4.34 | 2.60 | 0.69 | 0.52 | 0.30 | 1.50 | 3.05 | 0.51 | 0.04 | — | — | 0.03 | — | — | 0.06 |
| Ruby | 0.96 | 0.44 | 0.13 | 0.19 | 0.15 | 0.41 | 0.02 | 0.01 | — | 0.10 | — | 0.03 | — | 0.04 | — |
| Red Bobs Sel. | 17.65 | 20.25 | 21.31 | 25.24 | 26.23 | 32.69 | 39.58 | 54.91 | 55.86 | 71.46 | 71.54 | 65.10 | 47.04 | 57.65 | 52.85 |
| Ceres | 0.58 | 0.62 | 0.39 | 0.32 | 0.09 | 0.45 | 0.08 | 0.13 | 0.13 | 0.31 | — | 0.38 | 1.67 | 0.83 | 0.72 |
| Early Red Fife | 1.27 | 0.54 | 0.47 | 0.76 | 0.38 | 0.46 | 0.33 | 0.10 | 0.44 | 0.51 | 0.06 | 0.18 | 0.49 | 0.30 | 0.13 |
| Type IC | 9.51 | 6.68 | 6.72 | 6.84 | 8.58 | 6.60 | 4.90 | 4.13 | 3.32 | 3.14 | 1.02 | 1.93 | 0.94 | 0.93 | 1.09 |
| Reliance | — | — | — | — | — | — | 0.06 | 0.05 | — | 0.31 | 0.06 | 0.12 | 0.10 | 0.06 | 0.23 |
| Canus | — | — | — | — | — | — | — | — | — | — | 0.06 | — | — | — | — |
| Kota | 0.87 | 0.87 | 0.75 | 0.62 | 0.82 | 0.67 | 0.40 | 0.91 | 0.62 | 0.31 | 0.23 | 0.18 | 0.19 | 0.12 | 0.23 |
| Pioneer | 0.11 | 0.11 | 0.23 | 0.08 | — | 0.02 | 0.05 | 0.07 | — | — | — | — | — | — | — |
| Coronation | — | — | — | — | — | — | — | — | — | — | 0.11 | 0.06 | 1.18 | — | 0.77 |
| Renfrew | 0.87 | 0.34 | 0.07 | 0.03 | 0.02 | — | — | 0.07 | — | — | — | — | — | — | — |
| Kitchener | 0.96 | 0.31 | 0.33 | 0.04 | 0.51 | 0.02 | 0.06 | 0.08 | — | — | — | — | — | — | — |
| Huron | 0.49 | 0.03 | 0.24 | 0.11 | — | 0.02 | 0.02 | 0.01 | 0.04 | — | — | 0.06 | 0.19 | 0.02 | 0.02 |
| Preston | 0.06 | 0.10 | 0.20 | 0.07 | 0.06 | 0.24 | 0.05 | 0.01 | 0.04 | — | 0.06 | 0.03 | 0.09 | — | 0.09 |
| Stanley | 0.20 | 0.18 | 0.20 | 0.56 | 0.04 | 0.17 | 0.14 | 0.05 | — | 0.41 | 0.06 | 0.09 | — | 0.04 | 0.02 |
| Parkers Sel. | 0.73 | 0.48 | 0.09 | 1.28 | 1.23 | 0.34 | — | 0.31 | — | 0.10 | 0.11 | — | — | 0.02 | — |
| Fishers | 0.14 | — | 0.01 | 0.19 | — | 0.03 | — | — | — | — | — | — | — | — | — |
| Prelude | — | — | 0.02 | 0.01 | 0.02 | — | — | — | — | — | — | — | — | — | — |
| Quality | 0.06 | — | 0.02 | 0.01 | — | — | — | — | — | — | — | — | — | — | — |
| Miscellaneous | 2.49 | 0.52 | 0.11 | 0.01 | 0.62 | 0.12 | 2.62 | 2.90 | 1.23 | 0.62 | — | 1.96 | 0.19 | 2.50 | — |
| Axminster | — | — | — | 0.02 | — | — | — | — | — | — | — | — | — | — | — |
| Ladoga | 0.03 | 0.09 | 0.28 | 0.35 | 0.30 | — | 0.37 | 0.20 | — | — | — | — | — | — | 0.04 |
| White Russian | 0.34 | — | 0.01 | 0.07 | 0.04 | 0.07 | 0.02 | — | — | 0.03 | — | 0.03 | — | — | 0.06 |
| Early Russian | 0.15 | 0.03 | — | 0.01 | — | 0.05 | 0.05 | 0.06 | — | — | — | 0.03 | — | — | 0.04 |
| Percy | — | — | 0.01 | — | 0.02 | — | — | — | — | — | — | — | — | — | — |
| Java | — | — | 0.01 | — | — | — | — | — | — | — | — | — | — | — | — |
| Broatch Sel. | — | — | 0.01 | — | — | — | — | — | — | — | — | — | — | — | — |
| Club or Red Club | — | 0.14 | 0.01 | 0.06 | 0.02 | — | — | 0.01 | — | — | — | 0.06 | — | — | — |
| Speltoid | 0.15 | 0.13 | — | 0.05 | — | 0.07 | 0.05 | 0.03 | — | 0.03 | 0.06 | 0.03 | 0.19 | 0.08 | — |
| Durum | — | 0.01 | — | 0.01 | 0.02 | — | — | — | — | — | — | — | — | — | — |
| 6 Row barley | 0.01 | 0.04 | 0.07 | 0.01 | 0.02 | — | 0.02 | — | — | 0.10 | 0.06 | — | — | — | 0.02 |
| 2 Row barley | — | — | 0.02 | — | — | — | — | — | — | — | — | — | — | 0.06 | — |
| Tame oats | 0.01 | — | 0.04 | 0.01 | — | — | — | — | 0.31 | 0.03 | — | — | — | — | — |
| Wild oats | 0.03 | — | 0.01 | — | — | — | — | 0.03 | — | — | — | — | — | — | — |
| Number of cargoes | 30 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 13 | 16 | 14 | 25 | 6 | 25 | 25 |

TABLE A6.—VARIETAL COMPOSITION OF 2 MANITOBA NORTHERN WHEAT BASED ON 384 CARGOES. EX. VANCOUVER, B.C. FOR THE YEARS 1931-1946, INCLUSIVE IN PER CENT

| | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | 1939 | 1940 | 1941 | 1943 | 1944 | 1945 | 1946 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marquis | 6.86 | 16.13 | 12.63 | 9.19 | 46.75 | 37.43 | 31.58 | 24.79 | 21.64 | 10.57 | 43.65 | 4.69 | 1.29 | 12.48 | 12.88 |
| Garnet | 65.35 | 64.82 | 66.80 | 74.10 | 1.68 | 2.72 | 3.32 | 1.91 | 1.46 | 2.41 | 0.48 | 1.43 | 0.98 | 1.47 | 0.46 |
| Reward | 2.14 | 5.06 | 6.37 | 4.10 | 5.16 | 7.57 | 7.86 | 4.79 | 6.14 | 3.75 | 1.46 | 3.17 | 0.68 | 0.55 | 0.33 |
| Thatcher | — | — | — | — | — | — | 0.12 | 0.18 | 1.22 | 2.08 | 3.88 | 10.74 | 17.91 | 29.65 | 31.22 |
| Apex | — | — | — | — | — | — | — | — | 0.19 | — | — | 6.58 | 11.69 | 0.01 | 0.48 |
| Renown | — | — | — | — | — | — | — | — | — | — | — | 2.02 | 0.55 | 0.21 | 0.12 |
| Regent | — | — | — | — | — | — | — | — | — | — | — | 2.89 | 1.85 | 0.97 | 1.97 |
| Red Fife | 4.93 | 0.93 | 0.34 | 0.24 | 0.24 | 0.96 | 2.39 | 0.94 | 0.29 | — | — | 0.12 | — | — | 0.08 |
| Ruby | 0.13 | 0.43 | 0.20 | 0.23 | 0.06 | 0.89 | 0.09 | 0.07 | 0.15 | 0.08 | — | 0.03 | — | 0.04 | — |
| Red Bobs Sel. | 9.36 | 6.65 | 7.56 | 6.81 | 33.37 | 41.14 | 44.91 | 59.73 | 61.79 | 75.68 | 45.59 | 59.31 | 61.84 | 50.49 | 48.25 |
| Ceres | 0.78 | 0.65 | 0.10 | 0.46 | 0.52 | 0.15 | 0.17 | 0.27 | 0.39 | 0.41 | — | 0.78 | — | 0.69 | 0.46 |
| Early Red Fife | 1.09 | 0.44 | 0.36 | 0.42 | 0.22 | 0.68 | 0.82 | 0.50 | 0.43 | 0.50 | 0.97 | 0.81 | 0.55 | 0.29 | 0.08 |
| Type IC | 3.45 | 1.59 | 2.26 | 1.51 | 7.23 | 6.64 | 4.21 | 2.45 | 4.19 | 1.83 | 1.46 | 1.40 | 1.41 | 1.76 | 2.05 |
| Reliance | — | — | — | — | 0.04 | — | 0.05 | 0.09 | 0.24 | 0.33 | — | 0.09 | 0.25 | 0.04 | 0.08 |
| Kota | 0.20 | 0.41 | 0.55 | 0.25 | 9.50 | 0.56 | 0.43 | 0.61 | 0.15 | 0.17 | — | 0.12 | — | 0.04 | 0.27 |
| Pioneer | 0.02 | 0.30 | 0.25 | 0.22 | — | 0.02 | 0.05 | 0.03 | — | — | — | 0.09 | — | — | 0.02 |
| Coronation | — | — | — | — | — | — | — | — | — | — | — | — | 0.12 | — | 0.37 |
| Renfrew | 0.91 | 0.14 | 0.03 | 0.16 | 0.06 | 0.02 | — | — | — | — | — | — | — | — | 0.04 |
| Kitchener | 0.81 | 0.19 | 0.13 | 0.03 | 0.37 | 0.06 | 0.04 | — | — | — | — | — | — | — | 0.02 |
| Huron | 0.76 | 0.06 | 0.59 | 0.19 | 0.02 | — | 0.15 | 0.09 | 0.05 | — | — | 0.22 | 0.37 | 0.03 | 0.02 |
| Preston | 0.24 | 0.63 | 0.15 | 0.08 | 0.02 | 0.25 | 0.31 | 0.13 | 0.09 | — | 0.49 | 0.06 | 0.06 | 0.06 | 0.02 |
| Stanley | — | 0.33 | 0.46 | 0.23 | 0.14 | 0.28 | 0.24 | 0.11 | — | 0.25 | — | 0.22 | 0.30 | 0.19 | 0.06 |
| Parkers Sel. | 1.06 | 2.70 | 0.07 | 0.24 | 0.89 | 0.17 | 0.02 | 0.66 | — | — | 0.97 | 0.09 | — | 0.03 | 0.02 |
| Fishers | — | — | 0.02 | 0.02 | — | 0.02 | — | — | — | — | — | — | — | — | — |
| Prelude | — | — | 0.01 | 0.02 | — | — | — | 0.05 | — | — | — | — | — | — | — |
| Quality | — | 0.01 | 0.01 | 0.01 | — | — | — | — | — | — | — | — | — | — | — |
| Miscellaneous | 1.00 | 0.39 | 0.15 | 0.04 | 1.81 | 0.19 | 0.65 | 2.04 | 1.25 | 1.58 | 0.49 | 4.97 | — | 0.68 | — |
| Axminster | — | — | 0.08 | 0.07 | — | — | — | — | — | — | — | — | — | — | — |
| Ladoga | 0.32 | 0.01 | 0.39 | 0.03 | 0.30 | — | 0.37 | 0.22 | 0.05 | 0.08 | — | — | 0.06 | 0.06 | 0.21 |
| White Russian | 0.02 | 0.04 | — | 0.09 | 0.10 | 0.09 | 0.07 | — | — | — | — | 0.03 | — | 0.05 | 0.04 |
| Early Russian | — | 0.07 | — | 0.05 | — | 0.06 | 0.09 | 0.05 | — | — | — | — | — | — | 0.04 |
| Club or Red Club | 0.02 | 0.12 | 0.16 | 0.03 | — | — | 0.15 | 0.03 | 0.05 | — | — | — | — | — | — |
| Speltoid | 0.11 | 0.08 | 0.03 | 0.06 | 0.02 | 0.06 | 0.07 | 0.03 | — | 0.08 | 0.49 | 0.09 | 0.06 | 0.03 | — |
| Durum | — | 0.05 | — | — | — | — | 0.03 | — | — | — | — | — | — | — | — |
| Rye | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.02 |
| 6 Row barley | 0.17 | 0.09 | 0.13 | 0.11 | 0.02 | 0.04 | 0.02 | 0.05 | 0.15 | — | — | 0.03 | — | 0.11 | 0.04 |
| 2 Row barley | 0.07 | 0.01 | 0.01 | 0.08 | — | — | — | 0.07 | — | — | — | — | — | — | — |
| Tame oats | 0.16 | — | 0.02 | 0.01 | — | — | — | — | 0.05 | — | — | 0.03 | — | — | — |
| Wild oats | 0.01 | — | 0.03 | — | — | — | — | — | — | — | — | — | — | — | — |
| Number of cargoes | 29 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 11 | 7 | 2 | 25 | 10 | 24 | 25 |

TABLE A7.—VARIETAL COMPOSITION OF 3 MANITOBA NORTHERN WHEAT BASED ON 367 CARGOES. EX. VANCOUVER, B.C. FOR YEARS 1931-1946, INCLUSIVE

| | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | 1939 | 1940 | 1941 | 1943 | 1945 | 1946 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marquis | 33.05 | 27.71 | 17.81 | 14.97 | 25.23 | 6.46 | 5.29 | 19.57 | 23.53 | 14.00 | 11.24 | 3.19 | 6.68 | 8.60 |
| Garnet | 30.07 | 43.66 | 53.41 | 57.65 | 42.08 | 75.03 | 77.64 | 3.32 | 3.62 | 3.28 | 3.09 | 1.22 | 2.54 | 1.32 |
| Reward | 2.45 | 5.97 | 8.91 | 7.59 | 5.66 | 4.26 | 2.59 | 4.06 | 4.99 | 3.28 | 2.25 | 0.80 | 0.30 | 0.12 |
| Thatcher | — | — | — | — | — | — | — | 0.72 | 0.22 | 4.42 | 2.81 | 16.17 | 37.51 | 40.02 |
| Apex | — | — | — | — | — | — | — | — | — | — | 0.56 | 5.31 | 0.16 | 3.66 |
| Renown | — | — | — | — | — | — | — | — | — | — | — | 1.12 | 0.23 | 0.10 |
| Regent | — | — | — | — | — | — | — | — | — | — | — | 2.46 | 0.95 | 1.12 |
| Red Fife | 3.63 | 1.97 | 0.19 | 0.25 | — | 0.17 | 0.12 | 0.51 | — | — | 0.56 | 0.06 | — | — |
| Ruby | 0.11 | 0.63 | 0.27 | 0.44 | 0.06 | 0.31 | 0.12 | 0.03 | 0.05 | 0.76 | — | 0.04 | 0.02 | 0.02 |
| Red Bobs Sel. | 12.59 | 11.92 | 11.89 | 11.68 | 17.30 | 9.64 | 6.92 | 58.27 | 56.55 | 62.97 | 75.59 | 61.96 | 47.45 | 42.23 |
| Ceres | 0.78 | 0.29 | 0.29 | 0.37 | 0.47 | 0.34 | 0.10 | 0.72 | 1.43 | 0.50 | — | 0.24 | 0.64 | 0.40 |
| Early Red Fife | 1.86 | 0.89 | 0.44 | 0.40 | 0.47 | 0.29 | 0.07 | 1.03 | 1.26 | 1.14 | 0.84 | 0.46 | 0.25 | 0.14 |
| Type IC | 5.95 | 3.94 | 2.76 | 3.57 | 3.19 | 1.56 | 0.81 | 4.08 | 3.78 | 3.03 | 1.40 | 0.60 | 1.18 | 1.58 |
| Reliance | — | — | — | 0.01 | 0.14 | — | — | 0.14 | — | — | — | 0.02 | 0.25 | 0.03 |
| Canus | — | — | — | — | — | — | — | — | — | 0.25 | — | 0.08 | 0.07 | — |
| Kota | 1.48 | 0.47 | 0.61 | 0.32 | 0.43 | 0.24 | 0.10 | 0.77 | 0.38 | 1.01 | — | — | 0.02 | — |
| Pioneer | 0.03 | 0.38 | 0.40 | 0.15 | 0.08 | 0.01 | 0.07 | — | — | — | — | — | — | 0.03 |
| Coronation | — | — | — | — | — | — | — | — | — | — | — | 0.90 | — | 0.24 |
| Renfrew | 0.45 | 0.21 | — | 0.08 | 0.02 | — | — | 0.05 | — | — | — | — | — | — |
| Kitchener | 1.21 | 0.11 | 0.06 | 0.03 | 0.02 | — | — | 0.01 | — | 0.13 | — | — | — | — |
| Huron | 2.85 | 0.02 | 0.53 | 0.37 | 0.02 | — | 0.07 | 0.15 | 0.16 | — | — | — | 0.05 | 0.02 |
| Preston | 0.20 | 0.53 | 0.18 | 0.18 | 0.39 | 0.56 | 0.19 | 0.47 | 0.60 | 1.00 | — | 0.08 | 0.05 | 0.05 |
| Stanley | — | 0.19 | 0.72 | 0.21 | 0.22 | 0.26 | 0.12 | 0.22 | 0.10 | 1.14 | 0.28 | 0.14 | 0.02 | 0.02 |
| Parkers Sel. | 0.34 | 0.10 | 0.16 | 1.05 | 0.43 | 0.02 | 0.02 | 0.44 | — | 0.25 | 0.28 | 0.04 | 0.06 | 0.03 |
| Fishers | — | — | 0.01 | 0.01 | — | — | — | — | — | — | — | — | — | — |
| Prelude | — | 0.03 | 0.02 | 0.01 | — | — | 0.03 | — | — | — | — | — | — | — |
| Quality | 0.04 | 0.01 | 0.02 | — | — | — | — | — | — | — | — | — | — | — |
| Miscellaneous | 1.52 | 0.40 | 0.37 | — | 3.61 | 0.14 | 5.58 | 5.12 | 2.95 | 2.27 | — | 5.07 | 1.27 | — |
| Axminster | — | — | 0.01 | 0.04 | — | — | — | — | — | — | — | — | — | — |
| Pacific B. Stem | — | — | — | 0.07 | — | — | — | — | — | — | — | — | — | — |
| Ladoga | 0.05 | 0.15 | 0.21 | 0.08 | — | — | — | — | — | 0.13 | — | — | 0.05 | 0.07 |
| White Russian | 0.58 | 0.06 | — | 0.13 | 0.06 | 0.09 | 0.02 | 0.01 | — | 0.13 | — | — | 0.05 | 0.03 |
| Early Russian | 0.05 | 0.03 | — | 0.08 | — | 0.07 | — | 0.03 | — | — | — | — | — | — |
| Percy | — | — | — | 0.01 | — | — | — | — | — | — | — | — | — | — |
| Vermilion | — | — | — | 0.01 | — | — | — | — | — | — | — | — | — | — |
| Club or Red Club | 0.31 | 0.16 | 0.13 | 0.10 | 0.02 | 0.02 | 0.03 | — | 0.05 | — | — | — | — | — |
| Speltoid | 0.29 | 0.04 | 0.01 | 0.01 | 0.02 | 0.22 | 0.02 | 0.03 | — | — | 0.28 | 0.02 | 0.05 | — |
| Durum | — | — | — | 0.11 | — | — | — | — | — | — | — | — | — | — |
| 6 Row barley | 0.04 | 0.11 | 0.10 | 0.07 | 0.04 | — | 0.05 | 0.12 | 0.11 | 0.25 | 0.28 | — | 0.09 | 0.12 |
| 2 Row barley | — | 0.02 | 0.01 | — | 0.04 | — | — | 0.01 | — | — | — | — | — | 0.02 |
| Tame oats | 0.01 | — | 0.02 | 0.02 | — | — | 0.02 | 0.01 | 0.16 | — | — | — | — | — |
| Wild oats | 0.05 | 0.01 | 0.01 | 0.01 | — | — | — | — | — | — | — | — | 0.05 | — |
| Number of cargoes | 30 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 10 | 5 | 2 | 25 | 20 | 25 |

TABLE A8.—VARIETAL COMPOSITION OF 4 MANITOBA NORTHERN WHEAT BASED ON 46 CARGOES. EX. VANCOUVER, B.C. FOR YEARS 1938, 1943 AND 1946 ONLY IN PER CENT

| | 1938 | 1943 | 1946 |
|---|---|---|---|
| Marquis | 13.63 | — | 8.25 |
| Garnet | 10.77 | 5.08 | 2.68 |
| Reward | 6.16 | 0.22 | 0.11 |
| Thatcher | 0.19 | 19.45 | 46.50 |
| Apex | — | 3.54 | 6.93 |
| Renown | — | 3.09 | 0.50 |
| Regent | — | 7.07 | 1.02 |
| Red Fife | 0.40 | — | 0.07 |
| Ruby | 0.15 | — | — |
| Red Bobs Sel. | 58.79 | 55.47 | 31.19 |
| Ceres | 0.30 | 0.66 | 0.15 |
| Early Red Fife | 0.99 | 0.88 | 0.07 |
| Type IC | 2.99 | 0.88 | 1.67 |
| Reliance | 0.59 | — | 0.04 |
| Canus | 0.24 | — | — |
| Kota | 0.34 | — | 0.24 |
| Pioneer | — | 1.55 | — |
| Coronation | — | — | 0.30 |
| Kitchener | 0.03 | 0.22 | — |
| Huron | 0.15 | — | — |
| Preston | 0.63 | — | — |
| Stanley | 0.40 | — | — |
| Parkers Sel. | 0.51 | — | — |
| Miscellaneous | 1.88 | 1.55 | — |
| Ladoga | 0.13 | — | 0.02 |
| White Russian | 0.15 | — | — |
| Early Russian | 0.01 | — | — |
| Club or Red Club | 0.07 | — | — |
| Speltoid | 0.03 | — | — |
| 6 Row barley | 0.24 | — | 0.11 |
| 2 Row barley | — | 0.22 | 0.02 |
| Tame oats | 0.03 | — | — |
| Wild oats | 0.01 | — | — |
| Number of cargoes | 25 | 2 | 0.19 |

TABLE A9.—VARIETAL COMPOSITION OF 1 MANITOBA NORTHERN WHEAT BASED ON 26 CARGOES. EX. CHURCHILL, MAN. FOR YEARS 1935*-1946, INCLUSIVE IN PER CENT

| | 1935 | 1936 | 1937 | 1938 | 1939 | 1946 |
|---|---|---|---|---|---|---|
| Marquis | 64.71 | 69.03 | 63.55 | 60.42 | 65.63 | 16.34 |
| Garnet | 1.53 | 0.80 | 2.20 | 0.27 | 0.84 | 0.58 |
| Reward | 9.10 | 8.80 | 4.03 | 5.33 | 2.09 | 5.46 |
| Thatcher | — | — | — | 22.82 | 17.97 | 62.62 |
| Apex | — | — | — | — | — | 4.37 |
| Renown | — | — | — | — | — | 0.17 |
| Regent | — | — | — | — | — | 3.88 |
| Red Fife | 0.73 | 0.27 | 6.41 | — | — | 0.08 |
| Ruby | 0.37 | 0.13 | — | 0.13 | — | — |
| Red Bobs Sel. | 1.04 | 1.80 | 2.20 | 4.78 | 3.76 | 2.48 |
| Ceres | 1.40 | 1.20 | — | 0.68 | 1.04 | 0.41 |
| Early Red Fife | 1.65 | 3.00 | 4.40 | 0.82 | 0.42 | 0.41 |
| Type IC | 9.58 | 12.00 | 10.44 | 3.28 | 4.60 | 2.64 |
| Reliance | — | 0.27 | 0.37 | — | — | 0.17 |
| Canus | — | — | — | 0.27 | — | 0.08 |
| Kota | 0.37 | 1.53 | 1.65 | — | 0.63 | 0.08 |
| Pioneer | 0.18 | 0.06 | — | — | — | — |
| Coronation | — | — | — | — | — | 0.17 |
| Kitchener | 0.12 | — | — | — | — | — |
| Huron | 0.06 | — | — | — | — | — |
| Preston | 0.24 | 0.20 | — | — | — | — |
| Stanley | 0.37 | 0.40 | — | 0.13 | 0.21 | — |
| Parkers Sel. | 1.40 | 0.13 | — | 0.27 | — | — |
| Miscellaneous | 5.00 | — | 3.29 | 0.41 | 2.30 | — |
| Ladoga | — | — | 0.74 | 0.13 | — | — |
| White Russian | 2.01 | 0.07 | 0.18 | — | — | — |
| Early Russian | 0.06 | 0.13 | — | — | — | — |
| Club or Red Club | 0.06 | — | — | — | — | — |
| Speltoid | — | 0.07 | — | — | — | — |
| Wild oats | — | — | — | 0.13 | — | — |
| Number of cargoes | 7 | 6 | 2 | 3 | 2 | 6 |

* Years 1940, 1941, 1942, 1943, 1944, 1945 not represented.

TABLE A10.—VARIETAL COMPOSITION OF 2 MANITOBA NORTHERN WHEAT BASED ON 34 CARGOES. EX. CHURCHILL, MAN. FOR YEARS 1935*-1946, INCLUSIVE IN PER CENT

| | 1935 | 1936 | 1937 | 1938 | 1939 | 1943 | 1946 |
|---|---|---|---|---|---|---|---|
| Marquis | 55.21 | 66.13 | 45.39 | 35.69 | 35.75 | 1.45 | 10.92 |
| Garnet | 11.71 | 3.64 | 9.62 | 2.49 | 1.86 | 0.89 | 0.53 |
| Reward | 12.89 | 9.07 | 4.23 | 10.43 | 7.62 | 10.73 | 3.69 |
| Thatcher | — | — | — | 32.61 | 32.80 | 49.43 | 73.49 |
| Apex | — | — | — | — | 0.22 | 11.40 | 2.11 |
| Renown | — | — | — | — | — | 5.59 | 0.68 |
| Regent | — | — | — | — | — | 3.97 | 1.20 |
| Red Fife | 0.16 | 0.13 | 9.61 | 0.47 | — | — | 0.08 |
| Ruby | 0.55 | 0.13 | — | 0.23 | 0.07 | 0.06 | — |
| Red Bobs Sel. | 1.90 | 1.32 | 0.39 | 10.31 | 8.59 | 6.26 | 4.30 |
| Ceres | 1.11 | 2.98 | 0.39 | 1.06 | 1.12 | 1.23 | 0.23 |
| Early Red Fife | 2.93 | 2.65 | 6.50 | 0.23 | 3.58 | 3.75 | 0.08 |
| Type IC | 7.59 | 10.26 | 13.46 | 3.79 | 4.18 | 1.78 | 1.66 |
| Reliance | — | — | 0.39 | — | 0.22 | 0.34 | 0.08 |
| Kota | 0.87 | 1.59 | 1.16 | — | 1.04 | 0.17 | 0.08 |
| Coronation | — | — | — | — | — | — | 0.15 |
| Renfrew | — | 0.06 | — | — | — | — | — |
| Kitchener | 0.31 | — | — | — | — | — | — |
| Huron | — | — | — | — | 0.07 | — | — |
| Preston | 0.47 | 0.53 | — | — | 0.37 | 0.06 | 0.08 |
| Stanley | 0.40 | 0.33 | 1.93 | — | 0.07 | 0.11 | — |
| Parkers Sel. | 0.95 | 0.53 | — | — | — | — | — |
| Quality | — | — | — | — | 0.07 | — | — |
| Miscellaneous | 2.61 | 0.19 | 3.84 | 0.35 | 1.79 | 2.01 | — |
| Ladoga | 0.16 | — | 1.54 | 0.11 | — | 0.06 | 0.38 |
| White Russian | — | 0.13 | 0.77 | 0.11 | — | — | — |
| Early Russian | 0.08 | 0.06 | — | — | — | — | — |
| Percy | — | — | 0.39 | — | — | — | — |
| Club or Red Club | — | — | — | — | — | 0.06 | — |
| Vermilion | 0.08 | — | — | — | — | — | — |
| Speltoid | — | 0.20 | 0.39 | 0.59 | — | 0.50 | — |
| Rye | — | — | — | — | 0.07 | — | — |
| 6 Row Barley | — | — | — | 0.23 | 0.15 | 0.08 | — |
| 2 Row Barley | — | — | — | — | — | 0.08 | — |
| Tame oats | — | — | — | — | 0.37 | 0.08 | — |
| Number of cargoes | 6 | 6 | 1 | 2 | 6 | 7 | 6 |

* 1940, 1941, 1942, 1944 and 1945 not represented.

TABLE A11.—VARIETAL COMPOSITION OF 3 MANITOBA NORTHERN WHEAT BASED ON 19 CARGOES. EX CHURCHILL, MAN. FOR THE YEARS 1935*-1946, INCLUSIVE

| | 1935 | 1936 | 1937 | 1938 | 1939 | 1943 | 1946 |
|---|---|---|---|---|---|---|---|
| Marquis | 45.15 | 41.59 | 25.72 | 42.70 | 47.56 | 3.01 | 2.64 |
| Garnet | 28.29 | 36.14 | 41.39 | 6.30 | 3.22 | 2.58 | — |
| Reward | 8.43 | 6.81 | 11.11 | 7.70 | 10.32 | 12.69 | — |
| Thatcher | — | — | — | 15.75 | 13.87 | 30.10 | 89.73 |
| Apex | — | — | — | — | — | 17.63 | 2.23 |
| Renown | — | — | — | — | — | 10.97 | 0.40 |
| Regent | — | — | — | — | — | 3.66 | 1.20 |
| Red Fife | — | 0.79 | 3.70 | 1.40 | — | — | — |
| Ruby | — | — | — | — | 0.08 | — | — |
| Red Bobs Sel. | 1.20 | 1.00 | 1.02 | 7.70 | 9.00 | 4.36 | 1.20 |
| Ceres | 0.60 | 0.65 | 0.83 | 5.25 | 2.89 | 2.37 | — |
| Early Red Fife | 5.42 | 3.15 | 2.68 | 1.14 | 2.36 | 4.09 | — |
| Type IC | 3.61 | 6.96 | 4.53 | 3.15 | 4.54 | 1.72 | 1.02 |
| Reliance | — | — | 0.21 | — | 0.08 | 0.65 | — |
| Pioneer | 1.20 | 1.08 | 1.24 | 0.35 | 1.07 | 0.43 | — |
| Coronation | 1.80 | — | 0.41 | — | — | — | — |
| Renfrew | — | — | — | — | — | 0.21 | — |
| Kitchener | — | — | — | — | — | — | 1.62 |
| Huron | — | 0.22 | — | — | 0.17 | 0.43 | — |
| Preston | 0.60 | 0.43 | 0.21 | 0.35 | — | 0.21 | — |
| Stanley | 0.60 | — | 0.62 | 0.35 | — | — | — |
| Parkers Sel. | — | 0.43 | — | — | — | — | — |
| Miscellaneous | 2.41 | 0.07 | 6.12 | 7.00 | 4.12 | 4.73 | — |
| Early Russian | 0.60 | 0.21 | — | — | — | — | — |
| Club or Red Club | — | — | — | — | — | 0.21 | — |
| Speltoid | — | 0.43 | — | — | — | — | — |
| 6 Row Barley | — | — | 0.21 | 0.35 | 0.17 | — | — |
| Tame oats | — | — | — | — | 0.33 | — | — |
| Number of cargoes | 1 | 6 | 2 | 1 | 5 | 2 | 2 |

* Years 1940, 1941 and 1942 not represented.

TABLE A12.—VARIETAL COMPOSITION OF 1°, 2° AND 3° MANITOBA NORTHERN WHEAT. EX. MONTREAL, P.Q. FOR SEASON 1935

| | 1° 1935 | 2° 1935 | 3° 1935 |
|---|---|---|---|
| Marquis | 63.12 | 63.59 | 46.82 |
| Garnet | 1.35 | 5.90 | 26.25 |
| Reward | 9.70 | 9.23 | 9.04 |
| Red Fife | 0.86 | 2.21 | 0.16 |
| Ruby | 0.55 | 0.25 | 0.49 |
| Red Bobs Sel. | 2.54 | 2.09 | 1.98 |
| Ceres | 7.38 | 1.48 | 1.88 |
| Early Red Fife | 0.71 | 1.11 | 1.16 |
| Type IC | 6.52 | 5.66 | 6.10 |
| Reliance | 0.02 | — | 0.10 |
| Kota | 1.46 | 0.73 | 1.45 |
| Pioneer | 0.04 | 0.37 | 0.18 |
| Coronation | — | — | 0.02 |
| Kitchener | 0.07 | 0.12 | 0.04 |
| Huron | 0.11 | 0.12 | 0.16 |
| Preston | 0.40 | 0.12 | 0.14 |
| Stanley | 0.42 | 0.37 | 0.37 |
| Parkers Sel. | 1.81 | 4.05 | 1.06 |
| Fishers | — | — | 0.04 |
| Prelude | 0.06 | — | 0.02 |
| Quality | — | — | 0.04 |
| Miscellaneous | 1.83 | 1.62 | 2.12 |
| Ladoga | 0.57 | 0.37 | 0.18 |
| White Russian | 0.11 | 0.25 | 0.04 |
| Early Russian | 0.11 | — | — |
| Club or Red Club | 0.04 | 0.12 | — |
| 6 Row Barley | 0.07 | — | 0.08 |
| 2 Row Barley | — | — | 0.04 |
| Number of cargoes | 25 | 4 | 25 |

# SOIL FERTILITY STUDIES

## I. MANURE, FERTILIZERS AND LIME FOR FIELD CROPS AT STE. ANNE DE LA POCATIÈRE, P.Q.[1]

L. E. Wright,[2] J. R. Pelletier[3] and P. O. Ripley[4]

*Division of Chemistry, Science Service, and Division of Field Husbandry, Experimental Farms Service*

[Received for publication March 23, 1948]

It is generally known that on most Canadian soil types the majority of field and horticultural crops respond in a very marked degree to the application of a phosphatic fertilizer. In many instances available phosphoric acid has been found to be the chief limiting factor of crop production in so far as the supply of plant food constituents is concerned. The following report of results obtained in an experiment dealing with the use of manure, fertilizers and lime at the Dominion Experimental Station at Ste. Anne de la Pocatière, P.Q., furnishes additional support to the above mentioned conclusion. The chief object of the experiment was to determine a suitable combination of manure and fertilizer for the production of field crops.

The soil of the area is an upland podsol gravelly loam containing a considerable amount of shale particles. Analysis of a composite sample from the check plots in 1946 showed that 36.0 per cent failed to pass a 2 mm. sieve. The pH was 5.4, loss on ignition 6.07 per cent, nitrogen 0.22 per cent, $P_2O_5$ readily soluble in acid potassium sulphate (pH, 2) 23 p.p.m., and exchangeable CaO, MgO and $K_2O$ 0.185, 0.011 and 0.026 per cent, respectively.

The experiment was commenced in 1932 and the treatments were applied for the turnip crop in a four-year rotation of turnips, oats, clover and timothy on 1/50 acre plots in duplicate. On adjacent experimental areas the same treatments were commenced in 1933, '34 and '35. Consequently the yield data herein reported represent 14 crops of turnips, 13 of oats, 12 of clover and 11 of timothy hay. The treatments and crop yields obtained during the 14-year period 1932-1945 are tabulated in Table 1.

### DISCUSSION OF RESULTS

#### Yields

*Turnips.*—The response of the turnip crop to the application of a phosphatic fertilizer was outstanding. This result is demonstrated by comparisons as follows:

| Plot No. | Treatment | Yield of turnips (tons per acre) |
|---|---|---|
| 14 | Control | 4.02 |
| 5 | Superphosphate | 13.90 |
| 4 | Basic slag | 11.54 |
| 12 | N + K | 5.14 |
| 10 | N + P + K | 14.12 |

[1] Joint contribution from the Division of Chemistry, Science Service and Division of Field Husbandry' Experimental Farms Service. Scientific Contribution No. 151, Division of Chemistry, Science Service.

[2] Chemist in charge, Soils and Fertilizer Unit, Division of Chemistry, Science Service, Central Experimental Farm, Ottawa.

[3] Superintendent, Dominion Experimental Station, Ste. Anne dé la Pocatière, P.Q.

[4] Dominion Field Husbandman, Experimental Farms Service, Ottawa.

TABLE 1.—AVERAGE YIELDS 1932-1945

| Plot No. | Treatments per acre (applied once in the rotation for the turnip crop) | | Yields per acre | | | |
|---|---|---|---|---|---|---|
| | | | Turnips average of 14 years | Oats average of 13 years | Clover average of 12 years | Timothy average of 11 years |
| | | | (tons) | (bush.) | (tons) | (tons) |
| 1 | Ground limestone | 2 tons | 5.18 | 30.4 | 1.29 | 1.05 |
| 2 | Rock phosphate | 350 lb. | 9.10 | 30.0 | 1.49 | 1.22 |
| 3 | Hydrated lime | 2240 lb. | 5.53 | 36.3 | 1.51 | 1.22 |
| 4 | Basic slag | 750 lb. | 11.54 | 36.0 | 2.13 | 1.77 |
| 5 | Superphosphate | 750 lb. | 13.90 | 36.0 | 1.92 | 1.72 |
| 6 | Manure | 20 tons | 17.72 | 39.1 | 2.32 | 1.87 |
| 7 | Ground limestone<br>Manure | 2 tons<br>20 tons | 19.06 | 46.5 | 2.68 | 2.15 |
| 8 | Ground limestone<br>Superphosphate | 1 ton<br>500 lb. | 13.06 | 35.8 | 1.96 | 1.64 |
| 9 | Manure<br>Nitrate of soda<br>Sulphate of ammonia<br>Superphosphate<br>Muriate of potash | 10 tons<br>100 lb.<br>75 lb.<br>400 lb.<br>100 lb. | 17.63 | 39.5 | 2.37 | 1.81 |
| 10 | Nitrate of soda<br>Sulphate of ammonia<br>Superphosphate<br>Muriate of potash | 100 lb.<br>75 lb.<br>400 lb.<br>100 lb. | 14.12 | 30.5 | 1.76 | 1.33 |
| 11 | N + P as in 10 | | 13.12 | 34.8 | 1.85 | 1.39 |
| 12 | N + K as in 10 | | 5.14 | 28.5 | 0.95 | 0.85 |
| 13 | P + K as in 10 | | 12.14 | 34.5 | 1.46 | 1.21 |
| 14 | Check plot | | 4.02 | 25.5 | 0.93 | 0.84 |
| | Necessary difference for significance (P = 0.01) | | 2.57 | 3.8 | 0.27 | 0.26 |

When the phosphoric acid component of the complete fertilizer was omitted as in plot 12, the yield of turnips was very low and not significantly greater than that of the control plot 14.

When nitrogen and potash were omitted from the complete fertilizer as in plots 13 and 11, respectively, shown in Table 1, the yields declined slightly but the decreases were not significant. All three manure treatments whether alone, in conjunction with ground limestone or supplemented by a complete fertilizer gave significantly larger yields than the complete fertilizer. The application of lime alone as in plots 1 and 3 did not significantly increase the yield but it is noteworthy that although the addition of ground limestone to the manure treatment did not give a significant increase over the manure alone dressing, it resulted in the largest yield. The above results indicate that the application of a phosphatic fertilizer for the production of turnips on the soil under study is all-important.

To illustrate the trend of the yields of turnips over the experimental period under review the yields of certain plots are plotted in Figure 1.

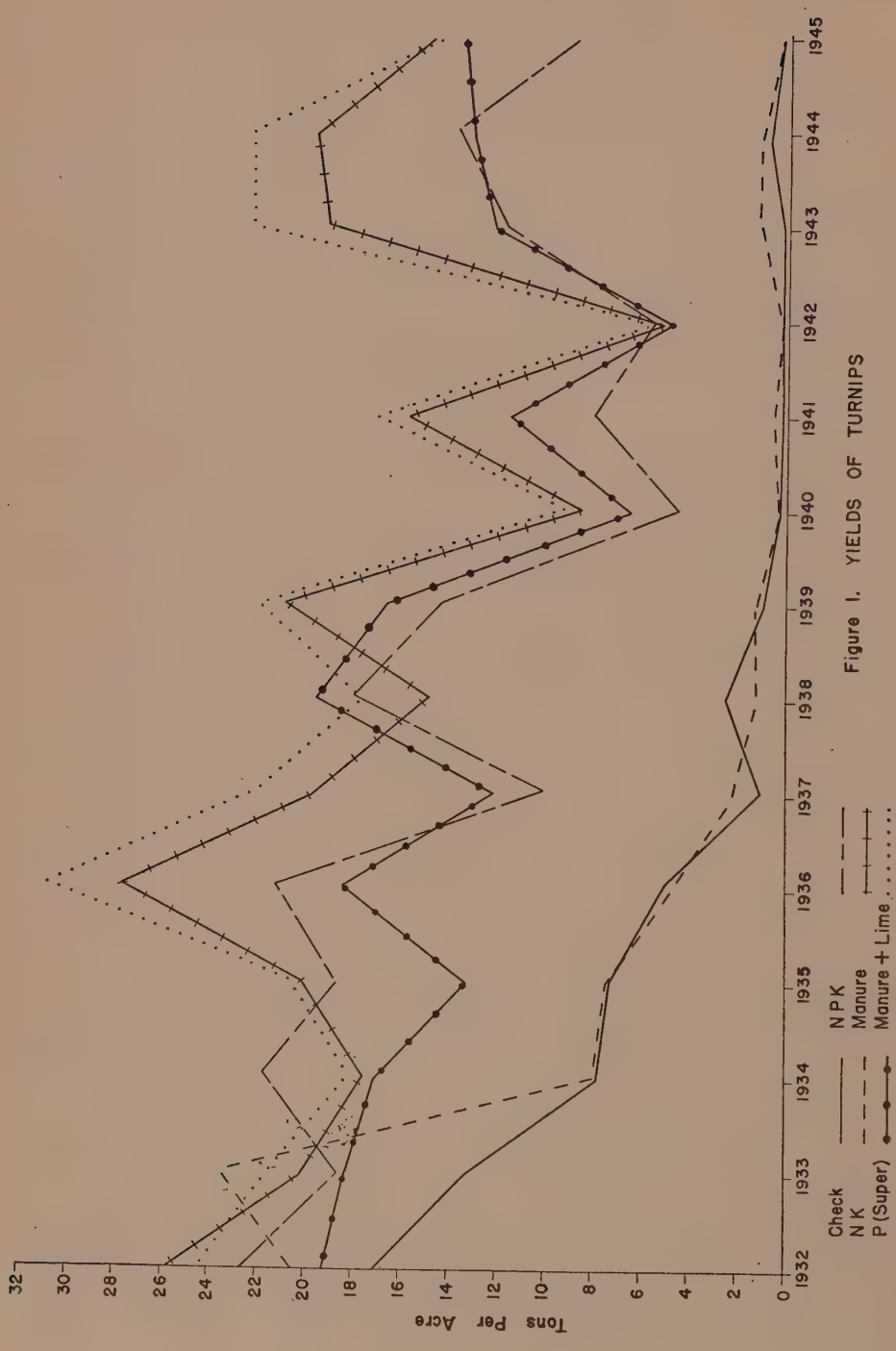


Figure 1. YIELDS OF TURNIPS

It will be noted that the yields from all treatments at the beginning of the experiment were quite satisfactory. However, on the plots where no phosphoric acid was applied, viz. the control and N K plots, the yields rapidly declined and remained at a very low level. On the plots which received phosphoric acid in the P, NPK, Manure and Manure + Lime treatments the yields varied considerably apparently due to seasonal conditions.

For instance, average yields prevailed on the fertilized plots from 1932 to 1935 and a study of precipitation records for the growing season May to September, as shown in Table 2, reveals a normal or slightly lower than normal rainfall for the whole five months. The highest yields for the duration of the experiment were obtained in 1936 in which season there was a high rainfall of 5.48 inches in May followed by normal precipitation for the remainder of the season. In 1940 and 1942 when turnip yields were lowest the precipitation was high in June, 6.54 inches and 7.09 inches, respectively and low in July, 2.10 inches in 1940 and 2.18 inches in 1942. In 1942 when all of the yields were low and fertilizer and manure were equally ineffective the dry July was followed by a drier August, 1.47 inches being recorded. The low yields in 1937 were apparently due to the very wet season when a rainfall of 29.37 inches was recorded during the five months and a record monthly rain of 9.21 inches was received in August. On the whole, however, the inclusion of manure in the soil management program has proved best for the growth of turnips on this type of soil.

TABLE 2.—PRECIPITATION, MAY TO SEPTEMBER, STE. ANNE DE LA POCATIÈRE, P.Q.

| | May | June | July | August | September | Total |
|---|---|---|---|---|---|---|
| 1932 | 1.30 | 3.45 | 4.46 | 5.83 | 5.03 | 20.07 |
| 1933 | 3.29 | 3.40 | 2.00 | 3.45 | 1.95 | 14.09 |
| 1934 | 1.85 | 4.87 | 2.94 | 3.77 | 2.19 | 15.62 |
| 1935 | 1.17 | 4.80 | 5.07 | 3.56 | 3.12 | 17.72 |
| 1936 | 5.48 | 3.24 | 3.39 | 2.46 | 3.33 | 17.90 |
| 1937 | 5.13 | 3.06 | 5.50 | 9.21 | 6.83 | 29.73 |
| 1938 | 2.47 | 3.19 | 6.01 | 6.09 | 6.59 | 24.35 |
| 1939 | 2.94 | 3.72 | 3.30 | 3.91 | 4.57 | 18.34 |
| 1940 | 3.46 | 6.54 | 2.10 | 3.21 | 3.07 | 18.38 |
| 1941 | 1.43 | 5.91 | 3.15 | 4.32 | 7.38 | 22.19 |
| 1942 | 1.99 | 7.09 | 2.18 | 1.47 | 3.85 | 16.58 |
| 1943 | 2.41 | 3.65 | 2.92 | 5.20 | 1.72 | 15.90 |
| 1944 | 1.18 | 2.65 | 5.53 | 3.55 | 3.91 | 16.82 |
| 1945 | 4.14 | 2.60 | 5.63 | 3.15 | 6.48 | 22.00 |

*Oats.*—All treatments, except that on plot 12 where the phosphoric acid of the complete fertilizer was omitted, gave significantly larger yields of oats than the control plot. As in the case of the turnips, the application of manure produced the highest yields, the increases over the control varying from 53 per cent, where the manure was used alone, to 82 per cent where the manure was supplemented with ground limestone. While there are certain inconsistencies in the response of the oat crop to the plant food constituents applied, the residual effect of the lime was quite marked on plot 7 where ground limestone was used with manure and on plot 3 where hydrated lime was used alone. The somewhat low yields on the NPK

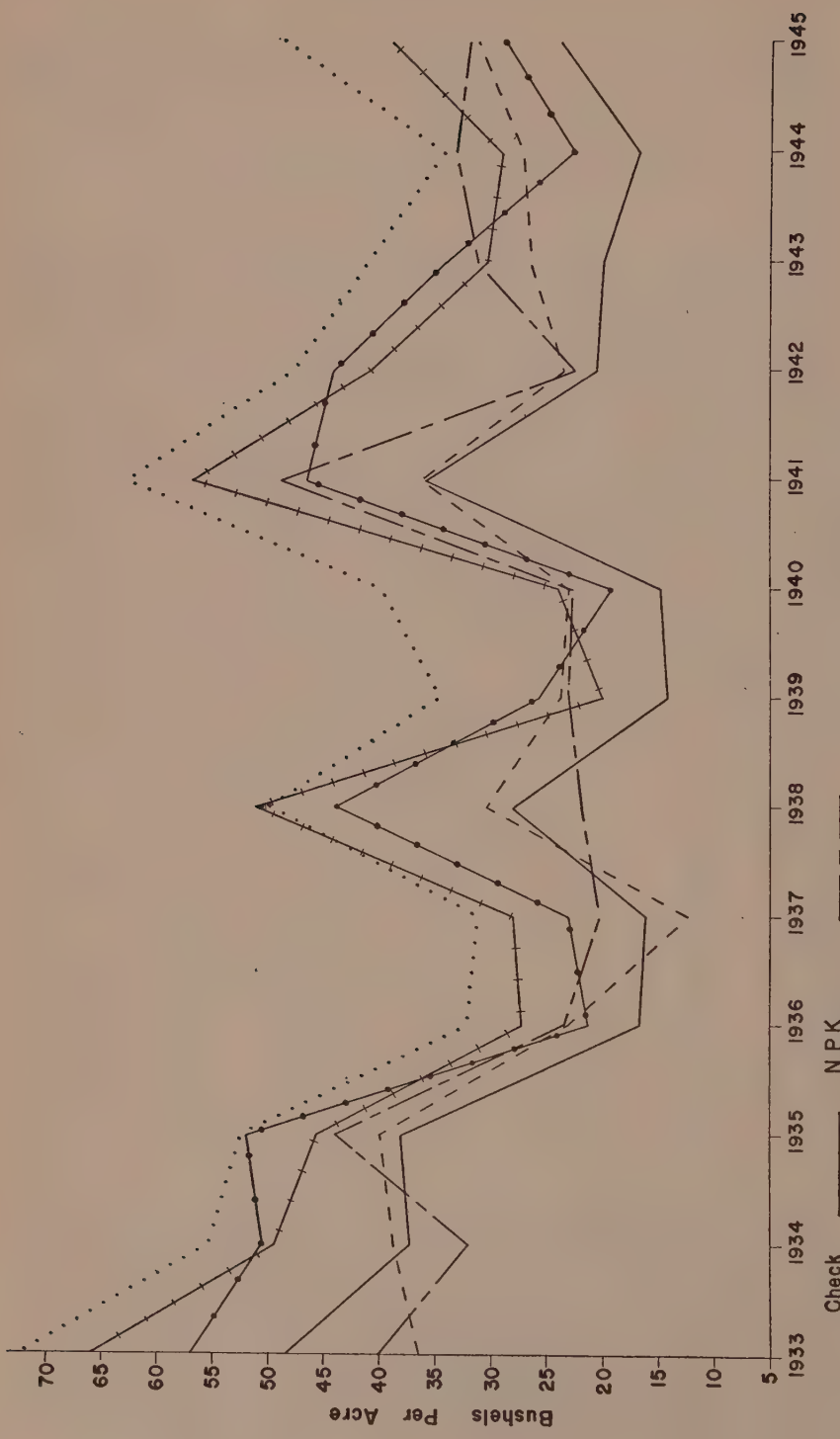


Figure 2. YIELDS OF OATS

plot are difficult to understand particularly when the NP and PK treatments gave significantly higher yields. The yields of oats from certain treatments for each year are plotted in Figure 2.

As in the case of the hoed crop the yields varied greatly with the season. The yields from the NPK treatment were consistently low from 1936 to 1940 and in 1942. This would account for the low average yields of oats from this treatment during the total experimental period. The other treatments showed a fairly uniform trend according to the season with the manured and superphosphate plots producing the best yields.

Precipitation records (Table 2), indicate the reasons for some of the season to season variations in oat yields as was the case with turnips. The yields were reasonably normal from 1933 to 1935 and so was the rainfall. The low yields in 1936 were affected by the wet May, with 5.48 inches of rain which interfered with seeding operations and early growth. The 1937 season was wet throughout and the yields of all crops in the rotation were low. High yields were obtained in 1938 although the seasonal rainfall was abnormally high. May, however, was reasonably dry with 2.47 inches of rain which allowed for early seeding and this was followed by a normal precipitation of 3.19 in June. The remaining three months all had a rainfall over 6 inches. No explanation is available for the low yield in 1939 which had normal rainfall throughout the season. In 1940 the low yield may have resulted from 6.54 inches of rain in June. In 1941 as in 1938 with high yields the month of May was dry, 1.43 inches of rain followed by ample rain for the remainder of the season.

*Clover Hay.*—The residual effect of the majority of the treatments applied two years previously was quite marked on the clover hay crop. As in the case of turnips and oats the largest yields were obtained where manure was applied. The combination of manure and ground limestone gave yields significantly higher than any of the other treatments. The importance of the application of lime and available phosphoric acid for the growth of clover hay is evident by the yields obtained on plot 4 where basic slag was used and on plot 8 where ground limestone and superphosphate were applied. Omission of the phosphoric acid component of the complete fertilizer on plot 12 reduced the yield to the same order as that of the control plot. The yields of clover hay, from selected treatments, obtained during the period 1934-45 are plotted in Figure 3.

As was found with the turnip crop, when phosphoric acid was omitted from the fertilizer treatment, viz. check and NK, the yields of clover hay were of the same order of magnitude and markedly lower than those where this element of plant food was applied in manure, a complete fertilizer or superphosphate.

In 1938 the season was especially favourable for the production of hay since there was ample rain. It was probably also favoured by the 1937 season which, although too wet for good crop growth generally, was ideal for establishing a stand of new seeding. The high yield in 1942 may be attributed to a high June rainfall of 7.09 inches followed by comparatively dry weather which provided for good harvesting conditions but was not dry enough to retard growth. The low yield in 1937 followed the same pattern as that of the other crops. Apparently the season was too wet even for the growth of hay.

*Timothy Hay.*—The residual effect of the treatments on the timothy hay crop was similar to that on the clover hay. The application of manure gave the largest yields and phosphoric acid and lime were the most effective of the plant food constituents applied. While the omission of the nitrogen and potash from the complete fertilizer (plots 13 and 11) did not significantly alter the yields as obtained on the NPK plots, leaving out the phosphoric acid component (plot 12) reduced the yield to the same order as the control plot.

The above results indicate that on this type of soil for the production of field crops the reduction of soil acidity with either ground limestone or slaked lime and the application of a dressing of manure will maintain soil fertility. Where the supply of manure is limited good results may be expected from the use of a small dressing of manure supplemented with superphosphate.

## EFFECT ON SOIL COMPOSITION

Variations in the composition of the soil at the end of the 14-year period were quite pronounced. In 1946 samples of the surface soil from certain of the plots were analysed and the results are presented in Table 3.

TABLE 3.—ANALYSIS OF SOIL SAMPLES

| Plot No. | Treatment per acre | pH | Moisture | Loss on ignition | Nitrogen | Readily soluble $P_2O_5$* | Exchangeable CaO** | Exchangeable $K_2O$** |
|---|---|---|---|---|---|---|---|---|
| | | | % | % | % | p.p.m. | % | % |
| 14 | Check | 5.4 | 1.9 | 6.07 | 0.22 | 23 | 0.19 | 0.026 |
| 5 | Superphosphate, 750 lb. | 5.4 | 2.3 | 7.85 | 0.27 | 91 | 0.20 | 0.014 |
| 6 | Manure, 20 tons | 5.6 | 2.4 | 7.88 | 0.28 | 93 | 0.21 | 0.031 |
| 7 | Manure, 20 tons<br>Ground limestone, 2 tons | 7.1 | 2.0 | 8.24 | 0.29 | 70 | 0.46 | 0.037 |
| 12 | Nitrate of soda, 100 lb.<br>Sulphate of ammonia 75 lb.<br>Muriate of potash, 100 lb. | 5.7 | 1.9 | 7.18 | 0.24 | 29 | 0.19 | 0.028 |

* Extracted with $KHSO_4$ at pH 2.0.
** Extracted with neutral N $NH_4OAc$.

The above analyses show that where ground limestone was applied every four years as in plot 7 the soil reaction was about neutral whereas on the other plots it was strongly acid. The readily soluble phosphoric acid of the soil on the plots which received this element in the fertilizer treatment was 3 to 4 times greater than that of the check and N + K plots. This might be due to the fact that the soil was originally low in phosphoric acid or that the continuous removal of this element by cropping without any return by fertilizer or manure has resulted in a very low level of this constituent. The latter explanation is supported by the trend of the yields shown in Figure 1. The low exchangeable potassium content of plot 5 which received only superphosphate might be due to depletion of that element by the increased crop yields from the phosphatic fertilizer. The

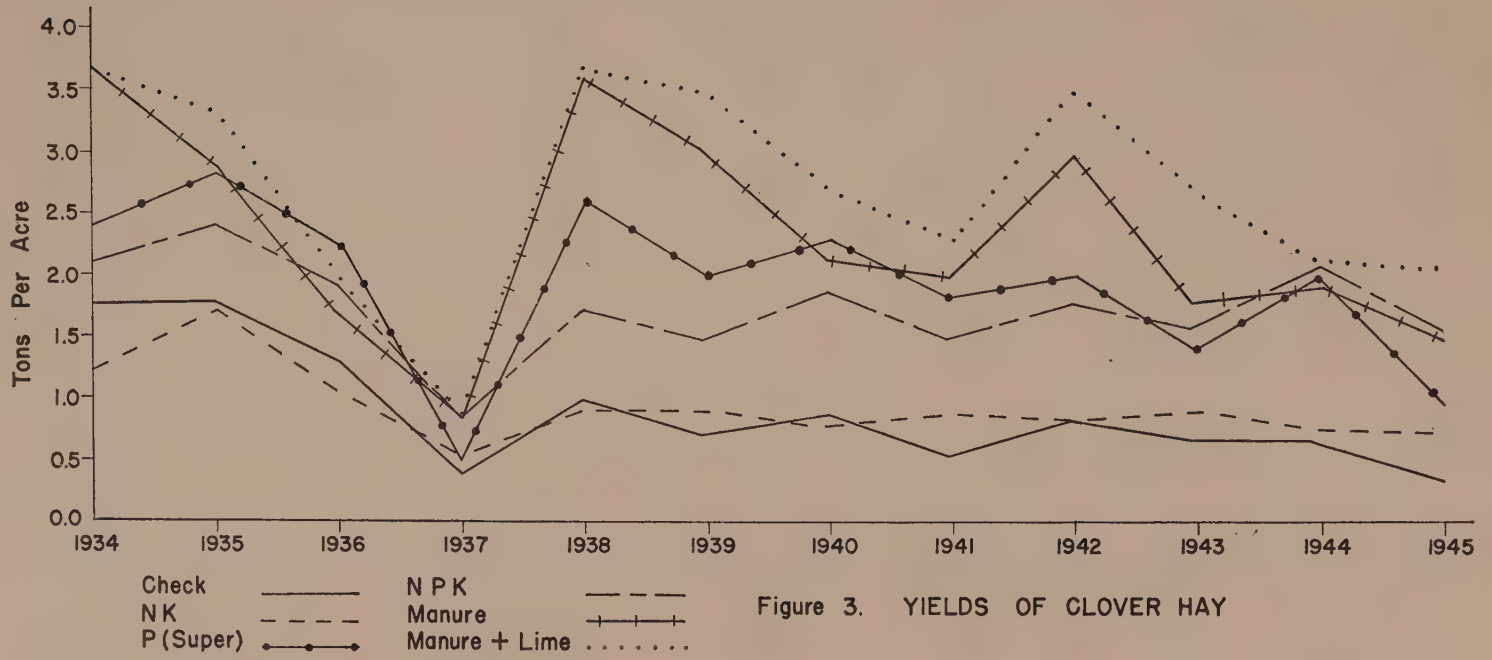


Figure 3. YIELDS OF CLOVER HAY

nitrogen and organic matter (by loss on ignition) contents of the soil on plots 5, 6 and 7 are appreciably higher than those of the check and N + K plots. This may be a reflection of the effect of the manure applied and the increased hay crop residue from the larger yields obtained on the former plots.

## SUMMARY

The effect of applications of nitrogen, potash, manure, three sources of phosphoric acid and two of lime were studied at the Dominion Experimental Station, Ste. Anne de la Pocatière, over the period 1932 to 1945. The above materials were applied to the hoed crop in a four-year rotation of turnips, oats, clover hay and timothy hay.

Nitrogen and potash applications had little effect on the yield of all crops of the rotation.

Phosphatic fertilizers applied to the hoed crop greatly increased the yields of turnips, clover hay and timothy hay and in some years benefited the oats crop. Superphosphate and basic slag applied alone proved about equally effective and both were distinctly superior to rock phosphate.

Where phosphoric acid was omitted from the fertilizer treatment the yields rapidly declined and remained at a very low level.

Ground limestone and hydrated lime slightly improved the yield of hay crops.

The application of manure gave the highest yields of all crops over the experimental period. It would appear that the best treatment for the growth of field crops on the soil under experimentation was a combination of manure and superphosphate.

The amount and distribution of the precipitation during the growing period greatly affected crop yields and fertilizer response.

## ACKNOWLEDGMENT

Acknowledgment is made to F. J. Sowden of the Division of Chemistry, Science Service, Department of Agriculture, for assistance in making the statistical examination of the field data.

# PHOSPHORUS STUDIES

## I. EFFECTS OF FLOODING ON SOIL PHOSPHORUS[1]

H. PAUL[2] AND W. A. DELONG[3]

*Macdonald College, Quebec*

[Received for publication July 29, 1948]

This paper is the first of a series of three, the primary objective of which will be consideration of the interrelation of the phosphatic, the sesquioxidic and the organic matter fractions of soils.

The present investigation was suggested by a problem in plant nutrition occurring in the sugar-producing area of the Lowlands of British Guiana. The soils of this area are heavy clays which are strongly acid, low in total phosphorus content and very low in easily-soluble phosphorus. The juice from sugar-cane produced on these soils is low in phosphorus. There is reason to believe that the quality of the juice would be improved and the yield of cane increased if an improvement in the phosphorus nutrition of the crop could be effected. Applications of rock phosphate and of superphosphate to these soils, however, have failed to produce significant responses either in yield of cane or in quality of juice.

For the past fifty years it has been customary to flood the cane-fields of the British Guiana Lowlands with water to a depth of about six inches and to maintain this flooded condition for at least six months, often longer, before replanting to cane. The cane plantations being on dyked land, flooding with river water is an easy matter. Molasses sometimes is added to the flood water. This practice, referred to locally as "flood-fallowing," is considered to have produced beneficial results from the standpoint of crop production.

In a recent survey of these soils by Hardy and Rodrigues (6) it was found that the easily-soluble phosphorus content (Truog method) of these soils sharply increased at depths of twenty to forty inches, that is, in the vicinity of the upper surface of the water-table. These authors suggested downward movement of phosphorus had occurred, particularly in the flood-fallowed soils.

In summary, the picture presented was that of soils decidedly low in total phosphorus and very low in acid-soluble phosphorus, periodically subjected to the anaerobic conditions of prolonged flooding followed by periods of considerable desiccation during the growth of the new cane, and containing an accumulation of acid-soluble phosphorus at the water-table level.

Consideration of this picture suggested that the flooding practice might be related, not only to the distribution of easily-soluble phosphorus within the profile (as already suggested by Hardy and Rodrigues), but also to the solubility and availability of the phosphorus in the part of the soil lying above the permanent but fluctuating water-table. It was decided to subject this hypothesis to experimental test. It was at that time (1946-7) quite impracticable, however, to obtain from British Guiana samples of

[1] Contribution from the Faculty of Agriculture, McGill University, Macdonald College, Quebec. Journal Series No. 244.

[2] Assistant Chemist, Department of Agriculture, Georgetown, British Guiana.

[3] Associate Professor of Chemistry.

soil in quantity sufficient for the experiments proposed. Hence it was decided to investigate the effects of flooding on the phosphorus status of a Canadian soil. In view of the fact that large areas of Eastern Canadian soils of heavy texture are imperfectly to poorly drained and are, therefore, subject to periodic water-logging, it was thought that the proposed investigation might yield results of interest to agriculturists both in this region and in British Guiana.

The Ste. Rosalie soil was selected for experimentation, primarily because it was a readily available, imperfectly drained soil of rather heavy texture, but also because it occupies a large area in the St. Lawrence Lowland Plain and is a soil of considerable agricultural importance. The Ste. Rosalie is an intrazonal soil derived from marine clay and having a weakly developed profile. The typical profile of this soil under cultivation may be described* as follows:

The 0-7-inch ploughed layer is a dark gray clay to clay loam, granular in structure, slightly plastic, and ranges in pH from 5.5 to 6.5. Immediately below the ploughed layer and extending to a depth of about 12 inches, the soil is a brownish-gray to rusty-brown clay with mottling of a rusty colour and with a few light-gray spots. The soil in this second layer has a weakly-developed granular structure, is plastic and ranges in pH from 5.7 to 6.5. The parent material at 24 inches and below is a gray clay with fine to medium blocky structure, very plastic, and ranging in pH from 6.7 to 7.3.

The large sample of Ste. Rosalie soil used in the present study was taken from the upper 12 inches of a cultivated field near St. Polycarpe, Soulanges Co., P.Q. The sample was air-dried, well mixed, and representative portions were sieved on a 2 mm. sieve. The soil passing this sieve was used for analysis and experimentation. The pH of the sample, 6.9, was somewhat higher than usual for the upper horizon of this soil. Physical analysis by the international pipette method showed that the sample contained 47.5 per cent total sand, 12.3 per cent silt and 31.2 per cent clay (0.002 mm.). The organic matter content (Walkley (12) method) was 2.7 per cent and the loss on ignition was 4.9 per cent.

## FLOODING TECHNIQUE

Samples of 800 gm. each were placed in conical-form glass percolators over small plugs of absorbent cotton which acted as filters for the percolates. These samples then were flooded with 800 ml. of distilled water or 800 ml. of one per cent glucose solution. This volume of flooding liquid gave a depth of about 3 inches over the soil. The depth of soil in the percolators was approximately 6 inches. Two conditions of flooding were employed, Free Drainage and Stagnant. In the former, free downward movement of the flooding liquid was permitted, and, when the liquid-level nearly reached the soil surface, additional liquid was added to restore the supernatant depth to 3 inches. Outgo of the flooding liquid was slow, the total volume added in a period of 30 days being about 3 liters. In the Stagnant systems the tubules of the percolators were closed by rubber tubing fitted with

* Private Communication, P. Lajoie, Soil Specialist, Experimental Farm Service, Dominion Department of Agriculture, Macdonald College, P.Q.

clamps. Flooding liquid was added only as required to compensate for evaporation losses. Both systems were operated at laboratory temperatures.

## METHODS OF ANALYSIS

Unless otherwise specified, all determinations of phosphorus were made by the Truog-Meyer procedure (10) using an Evelyn photo-electric colorimeter with a 660 mu filter. The results are expressed in terms of the element and on the air-dry soil basis. For the estimation of the total phosphorus content of the soil 0.5 gm. samples (100-mesh) were fused with sodium carbonate and the melt extracted with hot water. The solution was acidified and carbon dioxide expelled before colour development.

Easily-soluble phosphorus was extracted using the solution, the soil-solution ratio, and the time of shaking recommended by Truog (11), but employing 1.0-gm. samples of air-dry soil or equivalent weights of wet soil. The inorganic phosphorus content of the extract was determined colorimetically as indicated above, and the total phosphorus content similarly after having evaporated an aliquot of the extract to dryness in presence of a suitable amount of normal magnesium nitrate solution and ignited the residue. The residue was dissolved in 25 ml. of 0.5 N sulphuric acid solution and filtered before colour development. The difference between the results of these two determinations was assumed to represent easily-soluble, organically-combined phosphorus.

In the fractionation of soil phosphorus the method of Dean (2) was employed. The total NaOH-soluble phosphorus was determined after treatment of an aliquot of the solution with magnesium nitrate as described above. In the estimation of inorganic NaOH-soluble phosphorus an aliquot of the sodium hydroxide extract corresponding to 0.75 gm. soil was treated with one gram of charcoal (Darco G. 60), filtered, and the phosphorus content of the filtrate determined in the usual way. The difference between the total NaOH-soluble and the inorganic NaOH-soluble phosphorus determined in this way was assumed to represent organically-combined phosphorus soluble in NaOH-solution.

Anion exchange capacity was estimated by the method of Rubins and Dean (9). Colour due to organic matter was removed from the $NH_4F$ displacing solution by treatment with charcoal (Darco G. 60), after which the phosphorus content of the filtrate was determined by the method of Gerritz (5) as modified by Kurtz (8) to eliminate interference by fluoride ion. Light transmittance was measured as usual.

## RESULTS AND DISCUSSION

The duration of the first flooding experiment was 30 days. At the end of this time the liquids were withdrawn from the soils and the latter sampled for analysis at the 0 to 2 inch, 2 inch to 4 inch and 4 inch to 6 inch levels. The analytical samples consisted of weights of wet soil equivalent to one gram of air-dry soil. The easily-soluble inorganic and organic phosphorus contents of extracts from these samples were determined. The results obtained for the Free Drainage System, together with the pH values found for the moist flooded soils, are presented in Table 1. Similar data for the leachates obtained during the flooding period and for the original soil are included.

Examining first the changes in pH induced by flooding, it is seen from Table 1 that flooding with water only has tended to increase the pH slightly, whereas flooding with glucose solution has produced a remarkable decrease in this characteristic. Relative to the latter, it was noted that active anaerobic fermentation, accompanied by a marked "butyric" odour and considerable evolution of gas, occurred in the soil-glucose solution system, especially during the first week of treatment. Doubtless the acids produced in this fermentation are responsible for the change in pH of this system. A very slight evolution of gas was noted in the case of the soil-water system.

It will be noted also that the data for easily-soluble inorganic phosphorus shown in Table 1 suggest that a downward movement of this fraction has occurred, especially in the soil-glucose solution system. This indication is supported by the fact that small amounts of inorganic phos-

TABLE 1.—EFFECTS OF FLOODING, UNDER CONDITIONS OF FREE DRAINAGE, ON THE SOIL pH AND ON THE AMOUNT, NATURE AND DISTRIBUTION OF ACID-SOLUBLE PHOSPHORUS EXTRACTED BY THE TRUOG REAGENT

| Sampling depth (inches) | Flooded with water for 30 days | | | Flooded with 1.0 per cent glucose solution for 30 days | | |
|---|---|---|---|---|---|---|
| | pH | Inorganic phosphorus p.p.m. | Organic phosphorus p.p.m. | pH | Inorganic phosphorus p.p.m. | Organic phosphorus p.p.m. |
| 0 – 2 | 7.09 | 152 | 30 | 4.10 | 140 | 30 |
| 2 – 4 | 7.11 | 155 | 43 | 4.35 | 165 | 48 |
| 4 – 6 | 7.26 | 170 | 30 | 4.48 | 187 | 37 |
| In leachates | 6.80 | 0.600 | — | 4.40 | 0.640 | — |
| Before flooding | 6.92 | 160 | 8 | — | — | — |

TABLE 2.—EFFECTS OF FLOODING, UNDER STAGNANT CONDITIONS, ON THE SOIL pH AND ON THE AMOUNT, NATURE AND DISTRIBUTION OF ACID-SOLUBLE PHOSPHORUS EXTRACTED BY THE TRUOG REAGENT

| Sampling depth (inches) | Flooded with water for 30 days | | | Flooded with one per cent glucose solution for 30 days | | |
|---|---|---|---|---|---|---|
| | pH | Inorganic phosphorus p.p.m. | Organic phosphorus p.p.m. | pH | Inorganic phosphorus p.p.m. | Organic phosphorus p.p.m. |
| 0 – 2 | 6.88 | 161 | 41 | 5.26 | 149 | 53 |
| 2 – 4 | 6.94 | 159 | 44 | 5.94 | 151 | 50 |
| 4 – 6 | 7.03 | 166 | 34 | 6.19 | 162 | 53 |
| | Flooded with water for 60 days | | | Soil before flooding | | |
| 0 – 2 | 7.06 | 143 | 51 | 6.92 | 160 | 8 |
| 2 – 4 | 7.14 | 148 | 55 | — | — | — |
| 4 – 6 | 7.24 | 154 | 59 | — | — | — |
| | Flooded with water for 90 days | | | | | |
| 0 – 2 | 6.96 | 147 | 64 | — | — | — |
| 2 – 4 | 7.01 | 149 | 51 | — | — | — |
| 4 – 6 | 7.24 | 165 | 49 | — | — | — |

phate were found in the leachates. The data also indicate a definite accumulation of easily-soluble organic phosphorus under the conditions of the experiment, the amounts found being closely the same regardless of the nature of the flooding liquid used.

In Table 2 the corresponding results for the Stagnant systems are reported. Under this condition separate soil samples were flooded with water only for periods of 30, 60 and 90 days, respectively, with glucose solution for 30 days only. The same tendencies in respect of pH change are noted as in the case of the Free Drainage systems but in lesser degree. In the Stagnant systems also there is but little evidence of movement of easily-soluble phosphorus. The accumulation of easily-soluble organic phosphorus, on the other hand, is as great or somewhat greater than in the Free Drainage systems.

After withdrawal of the flooding liquids and taking samples for analysis from the two types of systems just considered, the wet soils were allowed to air-dry, were re-crushed to pass the 2 mm. sieve, and then re-analysed for easily-soluble phosphorus content. The results obtained are recorded in Table 3.

TABLE 3.—pH VALUES, AND THE AMOUNT AND NATURE OF ACID-SOLUBLE PHOSPHORUS EXTRACTED BY THE TRUOG REAGENT FROM FLOODED SOILS AFTER AIR-DRYING, WITH THE PERCENTAGE CHANGE IN THE INORGANIC PHOSPHORUS FRACTION INDUCED BY FLOODING AND AIR-DRYING

| Conditions of flooding | Acid-soluble phosphorus | | Per cent change in acid-soluble inorganic | pH air-dried soils |
|---|---|---|---|---|
| | Inorganic p.p.m. | Organic p.p.m. | | |
| Free Drainage System— | | | | |
| 30 days flooding with water | 156 | 26 | 2.6 | 7.05 |
| 30 days flooding with 1.0 per cent glucose solution | 42 | 21 | 73.8 | 4.20 |
| Stagnant System— | | | | |
| 30 days flooding with water | 141 | 29 | 11.9 | 7.20 |
| 60 days flooding with water | 118 | 32 | 26.3 | 7.34 |
| 90 days flooding with water | 114 | 37 | 28.8 | 7.25 |
| 30 days flooding with 1.0 per cent glucose solution | 67 | 23 | 58.1 | 5.48 |
| Not flooded— | | | | |
| Original soil | 160 | 8 | — | 6.92 |

Examination of Table 3 shows that, after air-drying, the amount of easily-soluble organic phosphorus extractable is in every instance (compare Tables 1 and 2) less than was obtainable from the still moist soils after flooding, although still about three times as great as was extractable from the original air-dry soil. The decrease in this fraction on air-drying may be due to breakdown of organic to inorganic phosphate. If such a breakdown has occurred, however, it has not resulted in a corresponding increase in the easily-soluble inorganic fraction, for, in every instance except for the 30-day-water-Free Drainage system, the values for inorganic phosphorus shown in Table 3 are definitely less than those for the original air-dry soil

TABLE 4.—EFFECT OF FLOODING ON THE ANION EXCHANGE CAPACITY OF THE STE. ROSALIE SOIL

| Conditions of flooding | Anion exchange capacity millimols phosphorus/100 gm. soil |
|---|---|
| Free Drainage System— | |
| 30 days flooding with water | 13.8 |
| 30 days flooding with 1.0 per cent glucose solution | 15.2 |
| Stagnant System— | |
| 60 days flooding with water | 15.2 |
| 90 days flooding with water | 15.2 |
| Unflooded— | |
| Original soil | 12.1 |

and less than those for the wet soils at the end of the flooding period (as shown in Tables 1 and 2). The percentage decreases from the amount of easily-soluble inorganic phosphorus found in the original soil, as shown in the third column of Table 3, are very considerable in the case of both the soil-glucose solution systems. They also are of an important order of magnitude for the longer periods of flooding with water under stagnant conditions.

It seems clear from the results reported in Table 3 that flooding of soils for extended periods, especially in presence of an abundant supply of easily-decomposable organic matter, and particularly when the flooding is followed by desiccation, may have a very undesirable effect upon the available phosphorus of the soil as measured by extraction with dilute solution of mineral acids.

In relation to these results it is pertinent to note that Allison and Scarseth (1) have proposed a biological method for removing oxides of iron from soils; that Ford (4) has demonstrated that hydrated oxides of ferric iron fix greater amounts of phosphate per unit weight of iron than does the anhydrous form of ferric oxide; and also that Follett-Smith and Robinson (3) working with the cane soils of British Guiana, and, more recently, Hester and Skelton (7) studying Ontario soils, have reported an increased soluble iron content in flooded soils. Further, Allison and Scarseth (1) observed that if soil previously incubated with glucose solution was washed with a 0.5 N solution of sodium chloride, the capacity of the residual soil for phosphorus fixation was less than that of the original soil. In view of these observations, it is thought that the results obtained in the present investigation reasonably may be explained as due to biological reduction of iron during the flooding phase, followed by re-oxidation during the desiccation phase, the net result of these phenomena being an increase in the phosphorus-fixing capacity of the sesquioxidic fraction of the Ste. Rosalie soil. Experimental evidence in support of this hypothesis was obtained in the following manner: A sample of soil flooded with glucose solution for 30 days was washed with 0.5 N NaCl solution before air-drying while a duplicate sample was air-dried without washing. On

estimation of the easily-soluble inorganic phosphorus extractable from the two samples it was found that the one which has been washed yielded 107 p.p.m., the one not washed only 42 p.p.m. of this phosphorus fraction. Further and more direct evidence that flooding with subsequent air-drying produced an increase in the reactivity of the sesquioxide fraction of the Ste. Rosalie soil was obtained from estimation of the anion exchange capacities of flooded samples and of the original air-dry soil. The results of these determinations are reported in Table 4.

Both the invariable occurrence of an increase in exchange capacity of the flooded and air-dried samples, and the magnitude of the increases found, indicate that significant changes in this soil property resulted from the treatments applied. It seems noteworthy that 60 days flooding with water only was capable of producing as large an effect as did 30 days flooding with glucose solution.

Application of the Dean fractionation procedure to flooded and air-dried samples supplied still further evidence of change in the reactivity of the sesquioxidic fraction. Thus, as will be seen from the data presented in Table 5, marked increases in the amounts of phosphorus present in the inorganic alkali-soluble fraction, generally considered to consist mainly of phosphates of iron and of aluminium, were produced by the experimental treatment.

TABLE 5.—PERCENTAGE DEVIATIONS FROM THE VALUES FOUND FOR THE DEAN FRACTIONS BY ANALYSIS OF THE ORIGINAL AIR-DRIED SOIL

| Treatment | Inorganic alkali-soluble | Organic alkali-soluble | Inorganic acid soluble | Inert |
|---|---|---|---|---|
| Free Drainage— | | | | |
| Flooded 30 days with 1.0 per cent glucose solution | 21.9 | 20.2 | −7.1 | −25.1 |
| Stagnant— | | | | |
| Flooded 30 days with 1.0 per cent glucose solution | 21.9 | 10.6 | −7.1 | −20.8 |
| Flooded with water 30 days | 11.3 | 7.7 | −2.1 | −12.6 |
| Flooded with water 60 days | 17.5 | 11.5 | −3.1 | −17.7 |
| Flooded with water 90 days | 25.0 | 5.8 | −7.1 | −19.9 |

Examination of Table 5 shows that the distribution changes resulting from treatment are consistent in sign throughout, that, in general, the greatest changes followed treatment with glucose solution, and that the extent of the changes produced in the water-flooded soils is in proportion to the duration of the flooding period. The magnitude of the decrease in the so-called inert phosphorus fraction suggests that, in so far as the Ste. Rosalie soil is concerned, this fraction contained substances reactive under the conditions of the experiment. It may be noted also that the absolute increases in the amounts of organic alkali-soluble phosphorus were less than the increases in easily-soluble organic phosphorus reported earlier. Possibly some of the latter fraction was decomposed to inorganic phosphate during the rather drastic alkali-extraction treatment of the Dean procedure.

Since the results indicated that an undesirable effect upon the "available" phosphorus content of the soil was produced by flooding followed by drying, it was of interest to determine whether or not this effect might be prevented. In this connection, current theory respecting the mechanism of phosphorus fixation in soils suggested that the application of lime to the moist soil after flooding might prevent the decrease in easily-soluble phosphorus. It was found, however, that the addition of saturated $Ca(OH)_2$ solution, at rates equivalent to from 2 to 7 tons of calcium carbonate per 2 million pounds of air-dry soil, to the moist soil from the 30-day glucose solution-Free Drainage system before air-drying failed to produce the desired result. This treatment did have some effect, the amount of extractable easily-soluble inorganic phosphorus being raised, on the average, from 42 to 57 p.p.m. The latter value, however, still represents a decrease of more than 60 per cent from the amount found in the original air-dry soil. This finding suggests that liming an acid soil may fail to prevent fixation of soluble phosphate by the sesquioxide fraction. Further observations relative to this point will be made in the second paper of this series.

The experimental results already recorded indicate that the desiccation phase is more important than the flooding phase in so far as effect on the extractability of easily-soluble inorganic phosphorus is concerned. It was of interest, therefore, to determine whether or not a decrease in this fraction of the soil phosphorus would occur in the moist soil after the excess of the flooding liquid had been withdrawn. In this connection, experiment showed that, when stored in a desiccator over a free water surface, the easily-soluble inorganic phosphorus content of samples of moist soil taken from the 30-day glucose solution-Free Drainage system remained constant (within the limits of experimental error) for a period of eight weeks. This result indicates that restriction of the free oxygen supply and prevention of desiccation will serve to prevent the decrease in extractable inorganic phosphorus found to result from air-drying. This finding may prove to be of practical value in respect of the phosphorus nutrition of sugar cane in the British Guiana Lowlands, where the height of the water-table within the soil profile easily may be regulated. This result also raises the question of the effect of improvement of drainage on the availability of phosphorus in the profiles of presently imperfectly-drained soils in Eastern Canada. Further study of the effects of different levels of oxygen supply and of varying degrees of desiccation is desirable.

As has been seen, on drying subsequent to flooding a part of the soluble phosphorus present in the Ste. Rosalie soil was converted to less readily extractable forms. It seemed probable soluble phosphate added to the soil also would suffer a similar change. An experimental test of this possibility was conducted using both wet and air-dried samples of flooded soil and a sample of the unflooded air-dry soil. Samples equivalent to one gram air-dry weight were taken; to each of these were added 5 ml. of $KH_2PO_4$ solution containing phosphorus equivalent to 250 p.p.m. of air-dry

soil. The mixtures were well stirred, placed in desiccators at zero humidity (over concentrated sulphuric acid) and at 100 per cent relative humidity (over water), and allowed to stand for 10 days. At the end of this period the samples over sulphuric acid were dry enough to remove with a brush; those over water were, of course, as wet as at the start. All samples were extracted with the Truog solution in the usual manner. The results are given in Table 6. In this table, the differences between the amounts of easily-soluble phosphorus found after the treatments just described and the sum of the amounts of easily-soluble phosphorus present in the samples prior to these treatments plus the amount of phosphorus added as $KH_2PO_4$, are expressed as percentages of this sum. The values so obtained are referred to as Percentage Fixation values.

TABLE 6.—FIXATION, BY WET AND BY AIR-DRY FLOODED AND UNFLOODED STE. ROSALIE SOIL, OF NATIVE PHOSPHORUS EXTRACTABLE BY THE TRUOG REAGENT AND OF PHOSPHORUS APPLIED AS $KH_2PO_4$ SOLUTION, ON STANDING FOR 10 DAYS AT ZERO AND AT 100 PER CENT RELATIVE HUMIDITY

| Conditions and duration of flooding | Percentage fixation | | | | | |
|---|---|---|---|---|---|---|
| | Wet soils | | | Air-dried soils | | |
| | Humidity per cent | | | Humidity per cent | | |
| | 0 | 100 | Diff. | 0 | 100 | Diff. |
| Free Drainage System— | | | | | | |
| 30 days flooding with 1.0 per cent glucose solution | 66.4 | 34.7 | +31.7 | 65.8 | 67.1 | −1.3 |
| Stagnant System— | | | | | | |
| 30 days flooding with water | 55.7 | 54.4 | + 3.3 | 41.4 | 41.4 | +0.0 |
| 90 days flooding with water | 66.9 | 55.1 | +11.8 | 58.9 | 54.9 | +4.0 |
| Unflooded— | | | | | | |
| Original soil | — | — | — | 14.6 | 17.2 | −2.6 |

TABLE 7.—PERCENTAGE OF APPLIED PHOSPHORUS FIXED BY WET AND BY AIR-DRY FLOODED AND UNFLOODED STE. ROSALIE SOIL ON STANDING FOR 10 DAYS AT ZERO AND AT 100 PER CENT RELATIVE HUMIDITY

| Conditions and duration of flooding | Wet soils | | Air-dried soils | |
|---|---|---|---|---|
| | Humidity per cent | | Humidity per cent | |
| | 0 | 100 | 0 | 100 |
| Free Drainage System— | | | | |
| 30 days flooding with 1.0 per cent glucose solution | +21.7 | −10.0 | +45.7 | +47.0 |
| Stagnant System— | | | | |
| 30 days flooding with water | +13.0 | + 9.7 | + 0.9 | + 0.9 |
| 90 days flooding with water | +21.4 | + 9.6 | +21.2 | +17.2 |

The salient feature of Table 6 is the very considerably increased phosphorus fixation in all the flooded samples as compared with that found for the unflooded soil. A second feature worthy of note is the fact that, under these experimental conditions, very considerable fixation of phosphorus occurred in all soil samples which previously had been flooded even when these were stored at 100 per cent relative humidity after addition of the $KH_2PO_4$ solution. The fact that the extent of fixation was similar, whether the added phosphate was applied to flooded soil still in the moist state or not until after the soil had been air-dried, suggests that the capacity for fixation originated in the flooding phase.

In presenting the data of Table 6 no attempt was made to differentiate between fixation of easily-soluble phosphorus native to the soil and fixation of phosphorus added as $KH_2PO_4$ solution. A definite answer in this connection awaits the application of the radioactive phosphorus technique, which was not available to us at the time these experiments were being conducted. A preliminary estimate of the amount of applied phosphorus fixed may be obtained, however, by calculating whether or not the amount of phosphorus fixed exceeded the total amount of easily-soluble phosphorus present in the soil before treatment. When this was done the data of Table 7 were obtained.

Examination of this table shows that the data indicate, in some instances at least, that substantial fixation of applied phosphorus had occurred. If one assumes that none of the easily-soluble organic phosphorus present in these soil samples was fixed, the values shown in Table 7 will be increased by about 8 per cent. Explanation of the apparent variations in behaviour of the different systems, and final clarification of the situation respecting the fixation of native and applied phosphorus, must await further investigation. It is believed, however, that the presently available data are strongly indicative of the possibility of the occurrence of fixation of applied phosphates in soils previously subject to conditions of flooding or of water-logging. It appears also that the degree of fixation of applied phosphorus may be considerably increased if an abundant supply of easily-decomposable organic matter is present during the flooding stage.

## SUMMARY

Experimental evidence has been presented which indicates that the prolonged flooding of soils, followed by desiccation to the air-dry state under aerobic conditions, may produce undesirable effects with respect to the solubility relations of both native soil phosphorus and phosphorus added as water-soluble phosphates. The results indicate that these undesirable effects are of special importance when an abundant supply of easily-decomposable organic matter is present. The evidence suggests that the decreased solubility of the phosphorus is a result of an enhanced reactivity of the sesquioxide fraction of the soil.

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## BOOK REVIEW

CATALOGUE OF INSECTICIDES AND FUNGICIDES, VOL. II: CHEMICAL FUNGICIDES AND PLANT INSECTICIDES, by D. E. H. Frear. Waltham, Mass: The Chronica Botanica Co. Ottawa, Canada: Thorburn and Abbott, Ltd. 153 pages. 1948. $5.50.

This work forms Volume 8 of the "Annales Cryptogamici et Phytopathologici" edited by Dr. Frans Verdoorn, Director of the Los Angeles State and County Arboretum.

The two volumes of the catalogue published to date are a compilation made after an extensive search of the literature and patents covering the results of testing over 10,000 candidate materials as insecticides and fungicides. Volume II deals with chemical fungicides, condensation products, plant product fungicides, miscellaneous fungicides and insecticides of plant origin. For each material tested the name, formula, synonyms, a brief note on toxicity, literature and/or patent citations are provided. As in Volume I, a coding system has been used based on the constituent chemical groups of each chemical compound. It is difficult to devise a simple coding system; therefore, in this case the author has provided, in Volume II, an alphabetical index of all compounds mentioned in the catalogue. This will be of particular advantage to the non-chemist who may have difficulty following the coding system.

This catalogue will be of interest to workers in entomology, plant pathology and agricultural chemistry and will be an invaluable aid to those engaged in screening new compounds for toxicity to insects and plant pathogens. Laborious literature and patent searches may be simplified by these two volumes.

The author points out, in the preface, that only the less commonly used materials are included in the present work. The value of the catalogue would be greatly enhanced if reference to the more important compounds now in use were included. No attempt has been made to include the new organic insecticides developed during and since World War II. It is hoped that supplementary volumes will appear which will keep this catalogue up to date, and that these volumes will review the important literature pertaining to recent developments of importance.

—H. HURTIG,
Entomology Section,
Experimental Station,
Suffield, Alberta.

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